



Principles of Ecosystem and Landscape-Scale Management

What Is Ecosystem Management and Why Is It Needed?

The Wisconsin DNR's mission is "To protect and enhance our natural resources: our air, land, and water; our wildlife, fish, and forests; and the ecosystems that sustain all life. To provide a healthy, sustainable environment and a full range of outdoor opportunities. To ensure the right of all people to use and enjoy these resources in their work and leisure. To work with people to understand each other's views and to carry out the public will. And in this partnership consider the future and generations to follow." This mission requires a long-term, broadscale approach to management that considers the interrelated nature of the chemical, physical, and biological components of a given area. Many of the basic principles of ecosystem management listed below are embedded in this mission. The overarching goal should be to provide the most complete set of viable and sustainable natural resources and recreational opportunities possible for future generations. Focusing management on a single species or particular recreational pursuit at the expense of other opportunities to the point where they may no longer be viable cannot accomplish this mission. A long-term, multiple-scale approach is needed to ensure that natural resources, recreational opportunities, and management flexibility are sustained for future generations. Ecosystem management provides just such an approach.

Ecosystem management is a philosophy and a process

rather than a program or activity. It considers human needs and values within the context of ecosystem capability and sustainability; the ways in which a management action may affect ecosystems and the species assemblages associated with and dependent upon them; and the ways in which management actions implemented at the stand or property level may affect resources at larger scales within a local landscape, region, or continent. Ecosystem management principles can be applied to many natural resource management decisions, and ideally, staff and resources would be integrated across relevant disciplines, programs, and administrative jurisdictions. A useful overview of ecosystem management applications may be found in Boyce and Haney (1997).

Practically speaking, an ecosystem management approach uses planning and analyses at multiple scales to help identify

the most important resources to manage from local, regional, continental, and global perspectives. This management approach identifies the best places in the state to manage, restore, and sustain these resources—which may include *natural communities*¹, aquatic features, selected habitats, and sensitive species

Ecosystem management is a system to assess, conserve, protect, and restore the composition, structure, and function of ecosystems, to ensure their sustainability across a range of temporal and spatial scales, and to provide desired ecological conditions, economic products, and social benefits.

—Wisconsin's Biodiversity as a Management Issue

populations—and to protect or restore key ecological processes. Ecosystem management uses a long-term approach to planning, recognizes the dynamic nature of ecosystems, and strives to sustain functional ecosystems that will continue to provide natural resources for future generations. In addition, ecosystem management includes the consideration of socioeconomic trade-offs that may result from pursuing those activities (e.g., forgoing the highest economic short-term gains to ensure that ecosystems and economies are sustained indefinitely).

¹Terms highlighted in green are found in the glossary in Part 3 of the handbook, "Supporting Materials." Naming conventions are described in Part 1 in the Introduction to the handbook. Data used and limitation of the data can be found in Appendix C, "Data sources used in the handbook," in Part 3 of the handbook.

The many concepts associated with ecosystem management are too numerous to discuss here. See Appendix D, “Descriptions of Ecosystem Management Concepts,” in Part 3 of the handbook (“Supporting Materials”) for more information. The basic principles of ecosystem management (Grumbine 1994) include the following:

- Ecosystem management is based on the science of ecology. Management direction and the guidelines and techniques used adapt and evolve as new information becomes available. Ideally, all management activities would be designed to contribute to the body of scientific knowledge about ecosystems.
- Ecosystem management considers management actions across multiple spatial and temporal scales.
- Good baseline assessments are needed to make good decisions and should be coupled with well-designed, effective, and practical monitoring programs to ensure that the desired or stated outcomes are being achieved.
- All natural communities, key habitats, and sensitive species are considered along with nongame and game species during the planning process to ensure they are appropriate to the planning unit, the landscape within which they are situated, and the management opportunities that have been identified.
- Humans are part of the ecosystem and ultimately depend upon it for their survival.
- Sustainable ecosystems support sustainable economies.
- Ecosystem management decision making considers the ecological and socioeconomic consequences of actions, with ecosystem sustainability as the major goal.
- Management is coordinated to reduce conflict and gridlock and improve efficiency.
- Public and private partnerships are essential components of ecosystem management.

Wisconsin’s flora, fauna, natural communities, and aquatic features are under increasing pressures from *invasive species*, land use changes, development, pollutants, and numerous other factors. Many of the state’s natural communities, aquatic resources, and other sensitive habitats are affected by fragmentation, stand isolation, and simplification, and the habitat base for many species is shrinking. It is critical, therefore, that resources be managed wisely. An important goal of ecosystem management is to ensure that Wisconsin’s natural communities, sensitive habitats, and diverse types of aquatic features are sustained somewhere in the state in sufficient abundance and in locations where they will be maintained

over the long term. This will require long-term vision, flexibility, and the ability to determine priorities. The protection and management of rare habitats such as prairies, savannas, beaches, and dunes and the species that are dependent upon them are obvious priorities because failure to act in a timely fashion can lead to losses that will be difficult to correct and could be irreversible. At the same time, we need to continue to manage for huntable populations of game animals and other common species in appropriate areas and where conflicts can be reduced or eliminated. Ecosystem management requires an evaluation of how much and where each type of management is needed as well as a careful assessment of the unintended consequences of management decisions, including those that are cumulative. It also provides direction to help identify the highest use for a particular area from an ecological perspective.

There are many land and water management entities, industries, and special interest groups in Wisconsin, each with a strong interest in the state’s natural resources. The basis of their interests varies widely and includes recreational pursuits, fulfillment of aesthetic, ethical, or spiritual needs, or direct support for their livelihoods. There is no primary, unifying goal for these groups, and many of them have a very narrowly defined focus. Understandably, individual natural resources stakeholders often like to see a greater emphasis on the resources of interest to them; however, resource management decisions are sometimes made without consideration for the impacts on other resources and users. By applying the principles of ecosystem management, we can take a broad and more inclusive approach to planning and management and ensure that a given landscape’s unique ecological characteristics are considered. This approach allows us to evaluate individual resource needs and desires within a broader ecological context. Ideally, these individual needs could be met in a way that does not compromise, and might even enhance, Wisconsin’s overall *biodiversity*. This is the underlying theme of this handbook.

Applying ecosystem management principles requires a consideration of the best ways to preserve or restore ecosystem function and diversity. A major goal is to maintain complex, diverse, functional ecosystems at multiple scales that are resilient to changes in the environment and to various disturbances. Maintaining species and habitat diversity, identifying where and how to best establish and maintain connecting *corridors*, and recognizing missing or diminished ecosystem functions and components to restore are examples of these important considerations. Providing a number of examples of the same ecosystem at different locations throughout the state should help to mitigate the impacts of growing human populations, changing land uses, invasive species, and climate change and provide additional management options in the future (Noss and Scott 1997).

How Does Ecosystem Management Differ from Current Management Approaches?

In some respects, ecosystem management is similar to what has been done in the past. It shares many of the same tools and some of the prescriptions that have been used before. However, an ecosystem management approach also focuses on how, where, when, and at what scale we apply these tools. For example, if we are to sustain all natural communities, significant habitats, and aquatic ecosystems somewhere in the state, we cannot emphasize management for common, widespread habitat generalists everywhere. Rather, we examine and identify the best and most strategic opportunities to maintain sensitive, rare, and declining communities, habitats, and species while continuing to provide for the more common species elsewhere. Management targets and their locations are determined by using the many tools and concepts of ecosystem management (e.g., see the “Conservation Design” section below and Appendix D, “Descriptions of Ecosystem Management Concepts” in Part 3 of the handbook). Ecosystem management also explores ways in which to integrate programs and identify complementary, mutually beneficial goals and objectives that optimize efficiency and success in sustaining natural resources. Only well-designed, practical monitoring programs will accomplish this.

Ecosystem management uses an integrated, science-based approach to managing natural resources that is consistent with current management philosophies. However, the ecosystem management approach differs in its need to evaluate natural resources at multiple scales, including planning land and water management (for product extraction, recreation, preservation, and restoration of degraded or missing ecosystem components) at a regional or statewide level. These broad scales are used to ensure that management is compatible with the ecology of a given ecological landscape or other unit and that important components of ecological diversity and ecosystem function are not inadvertently lost or diminished.

Planning at broad scales is often emphasized because landscape context and ecological connectivity of related ecosystems are necessary considerations and occur at broader scales than, for example, an individual forest stand or some other managed parcel of land. However, ecosystem management includes consideration for the full range of scales from a *microsite*, to an ecological landscape, to the state, or even to a multi-state region (see the “Conservation Design” section below).

In addition to utilizing multiple spatial scales, ecosystem management requires consideration of different temporal scales. For example, considering only the present or near

future is not ecosystem management because long-term considerations are often needed. Change, perhaps the only true constant in ecosystems, usually happens over long time periods.

The application of ecosystem management focuses on the resources most in need of management attention (i.e., species, habitats, and natural communities). It assesses the ecological resources of the state, determines how important Wisconsin is to sustaining these resources from a regional and global perspective, and highlights the areas in the state that are best suited for maintaining these resources.

Using ecosystem management does not imply or require the restoration of our lands and waters to the conditions that existed prior to Euro-American settlement, nor does it endorse the status quo. Strategic planning should be used to identify areas that provide the most effective opportunities to sustain natural resources as planners, landowners, and managers strive to meet human needs while managing, restoring, and sustaining native ecosystems of all types across their full range of natural variation.

In order to incorporate human needs into planning, the application of ecosystem management involves a long-term perspective in considering both ecological and socioeconomic impacts of management options and searches for ways to sustain both natural resources and economic activities over time. The “Ecosystem Management Planning” and “Implementing Ecosystem Management” sections in this chapter and the “Integrated Ecological and Socioeconomic Opportunities” section in Chapter 6, “Wisconsin’s Ecological Features and Opportunities for Management,” present more detailed ways to accomplish these goals.

Ecosystem management can be compatible with “*working landscapes*” from which natural resources are sustainably extracted. People and the economy are dependent upon natural resources to survive, so natural resources must be sustained to maintain economic sustainability over the long term. It is important to ensure that human uses do not compromise the capacity of natural resources for self-renewal since removing natural resources in an unsustainable manner does not benefit natural communities, the economy, or the human population over the long term. However, defining “sustainability” can be challenging, and definitions may differ based on goals and values. As an example, sustainable forestry is “the practice of managing dynamic forest ecosystems to provide ecological, economic, social, and cultural benefits for present and future generations” (from Ch. 28.04(1)e, Wis. Stats.). Which of these benefits (“ecological, economic, social, and cultural”) is emphasized and whether the benefits are for “present or future generations” are important to clarify when sustainability measures are created and implemented. There are many Wisconsin DNR documents and policies designed to ensure that natural resources are managed sustainably. In addition, virtually all of the lands managed by the DNR are “dual-certified” by the Forest Stewardship Council and the Sustainable Forestry Initiative, and



Large expanse of surrogate grasslands within the boundary of the Southwest Wisconsin Grassland and Stream Conservation Area. This area has the potential to support human economic needs while provide viable breeding habitat for declining grassland birds. Photo by Cathy Bleser, Wisconsin DNR.

both require adherence to their standards for sustainability in order to maintain certification.

To practice ecosystem management, it is important to consider the ecological potential of a management site, how it is related to its surroundings, and how it could fit into the larger ecological context or meet broader regional ecological needs in the future. Changes to the current management regime may or may not be the best choice, depending on the present condition of the site, its future management potential, the surrounding landscape, and how it fits into a broader regional context with respect to management needs and opportunities. Additional considerations pertinent to ecosystem management implementation may be found in Christensen (1997).

Site-level management, without considering the context of the surrounding landscape and the organisms that use it, is not ecosystem management. Also, using intensive management (or the same treatment) at every location in the landscape within a relatively short time frame (e.g., on all forest stands within a landscape) is not ecosystem management (Franklin 1997). Ecosystem management does not require that the same techniques be applied everywhere or simultaneously, and it recognizes differences in ecological and socioeconomic capabilities in different areas; however, the broad goals for sustaining ecosystems should apply equally throughout the state.

The assumption that by managing for certain featured species all the other species appropriate for that habitat or site will “take care of themselves” is not consistent with ecosystem management. Under certain circumstances, rare species may need special management attention to enable them to reestablish and sustain their populations, but the effects of that management on other species and their habitats should always be considered. A thorough analysis of such situations can often reduce or eliminate conflicts and ensure that the future management objectives will be consistent and compatible.

Ecosystem management is not a panacea that will solve all of our environmental problems. Current stressors to the state’s natural resources include invasive species; increased pressure to extract resources or use them unsustainably; development pressures that contribute to habitat fragmentation and loss, diminished water quality and degraded aquatic habitats due to siltation, pollutants, and water withdrawals; and climate change. These stressors are related to a growing human population putting pressure on a finite resource base and will present major challenges to resource managers and users in the future. However, ecosystem management will help preserve the biodiversity of the state in the short term and, where implemented, may preserve more management options to combat these stressors over the long term.

Ecosystem Management Planning

The principles of ecosystem management can be easily understood yet difficult to apply. Ecosystem management requires thinking at multiple scales; cooperation with multiple landowners; participation of interested segments of society with diverse philosophies, desires, and goals; and the participation of natural resource managers from the appropriate disciplines. An ecosystem management approach may even call long-standing paradigms into question or require us to examine our motivations and values. Although incorporating ecosystem management principles into planning efforts may create additional work up front, it can pay large dividends once the plans are completed. Thorough planning allows us to clarify ecological objectives and adequately evaluate the ecological capabilities of a particular area. For a discussion of some of the institutional challenges associated with ecosystem management implementation, see Cortner et al. (1996).

Managing for a diverse array of plants and animals from a statewide perspective will not always be compatible with other objectives, such as maximizing the number of a few game species or the economic return on timber within a given area over a given time period. However, limiting ourselves to the same tools, benefitting the same species, and working at the same scales throughout the state will lead to a simplified and homogenized environment and will not adequately support biodiversity. This could also make it more difficult to survive the stressors facing us in the future, such as climate change, the advance of invasive species, and land use changes that alter the abundance, condition, or pattern of natural resources. The habitat base is shrinking, and different management approaches may be needed to combat these stressors and maintain diverse and sustainable resources for future generations. Maintaining game species and maximizing timber production will always be a part of the natural resource manager's toolbox, and there will be many places where this will be the primary objective. However, management and planning is needed at multiple scales to achieve these objectives while maintaining Wisconsin's biodiversity and sustaining our natural resources.

Factors to Consider

An ecosystem management approach applies principles drawn from a wide range of disciplines including ecology, landscape ecology, population biology, conservation biology, the social and political sciences, conservation design, and adaptive resource management. This section highlights some of the factors to consider when proposing and planning ecosystem management. The "Conservation Design," "Implementing Ecosystem Management," and "Adaptive Resource Management" sections below provide information on applying the factors and concepts to management.

Resources Important to Maintain in an Area

One of the most important premises of ecosystem management is to think at multiple scales. Often ecosystem management planning is begun by taking a broad, long-term approach; however, throughout the planning process many scales may need to be considered. Ecosystem management for a given area begins by looking at what resources are important for Wisconsin to maintain, including regionally or globally important natural communities, habitats, or species populations that are declining, rare, or at risk. This is especially important when Wisconsin has a relatively large part of the global acreage or population. Such habitats or species may need special attention and warrant priority over other more common or widespread species and habitats (especially if these are already being managed successfully at other locations), depending on the reasons for their rarity or decline and what the specific remedies (management needs) might be. This does not mean that common species and habitats should be ignored, because "keeping common

species common" is also a basic tenet of ecosystem management. But if there is an opportunity to preserve or restore a rare or declining habitat or species in an appropriate location (e.g., overgrown, degraded barrens vegetation in a location that historically supported the Pine Barrens community), that may be identified as a priority consideration over maintaining a common, widespread, and secure species or habitat such as a *pine plantation* or aspen stand. For planning at the stand or some other local level, ecosystem management considers the conservation opportunities offered by the site and how proposed management actions may affect local or regional biodiversity. In some cases, the best choice may be to continue on the current path, while in other cases a change may be warranted to take advantage of the identified management opportunities.

Summary information that identifies those species and habitats that are important to manage in Wisconsin can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," in the individual ecological landscape chapters, and in Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 of the handbook ("Supporting Materials").

Is This a Good Location to Manage a Particular Resource?

Ecosystem management planning includes an evaluation of the ecological capability of the project planning area. Often, vegetation that occurred prior to Euro-American settlement suggests what the ecological capability of the area might have been and which natural communities might effectively and appropriately be managed there now. However, other baseline data are usually needed to make this determination, whether through formal inventories or other sources. The



Quaking aspen (Populus tremuloides) is the second most common timber type in northern Wisconsin. Aspen is typically managed on short rotations (45–60 years) to provide timber products such as pulp and habitat for certain common and widespread game species in Wisconsin. Photo by Jeff Martin.

goal is to ensure that management will be consistent with the ecology of the area, providing better chances for success and making management easier and more effective. Again, rare or declining species or habitats identified in the area should be given special consideration, especially if they are rare globally and Wisconsin has a large part of the global population. Some decisions about rare species will require further evaluation, such as the uncertainties about how to address species that are rare because they are at the edges of the ranges in particular parts of Wisconsin.

Some of the best areas in the state to emphasize management for specific natural resources are identified in Chapter 6, in the individual ecological landscape chapters, and in Appendix E, “Opportunities for Sustaining Natural Communities in Each Ecological Landscape,” in Part 3 of the handbook.

Consider the Long Term

Another basic premise of ecosystem management is to consider management impacts over the long term. A site should be evaluated, not only for what it is today, but also for its past condition and future ecological potential. The management that has occurred at a given site in the past may not be the best management for that site in the future, and some goals may require long time periods to achieve. Also, monitoring is needed to reveal trends and changes over time.

Consider the Needs of People

Because humans are part of ecosystems, human needs are part of any ecosystem management decision. Ecosystem management and ecological goals are developed to ensure that ecosystems upon which human existence depends are sustained. History has taught us that sustainable ecosystems support sustainable economies over the long term. Ecosystem management provides for human uses as long as the capacity of natural resources for self-renewal is not compromised.

It is important to maintain a balance between the use and extraction of natural resources and the maintenance of ecosystem diversity and function. Management that solely maximizes resource extraction has resulted in the loss of ecological diversity in the past, and care must be taken to prevent the loss of ecosystem productivity and function over time. Where appropriate and feasible, management for product extraction could provide products for human use while sustaining ecological diversity. For example, periodically harvesting jack pine (*Pinus banksiana*) for pulp on lands surrounding sites managed to restore and maintain barrens communities can provide semi-open habitat and benefit many barrens species while also providing forest products (see the “Conservation Design” section below for an example). Carefully planning the size, shape, location, timing, and postharvest treatment of harvest activities can be beneficial by temporarily increasing both the habitat area available and habitat connectivity. Monitoring is essential to determine whether or not a given management design or scenario is working.

The same is true for providing recreational opportunities. The mission of the Wisconsin DNR is to protect and sustain natural resources for future generations and to provide recreational opportunities for people. Attempting to provide too many types of recreational opportunities at one site, especially those containing sensitive resources, can cause or exacerbate declines in biological diversity. For example, intensively managing much of northern Wisconsin to provide habitat for white-tailed deer (*Odocoileus virginianus*) and Ruffed Grouse (*Bonasa umbellus*) can result in the direct or indirect loss of rare or declining species that require larger blocks of unfragmented older forest habitat. In addition, maintaining high populations of white-tailed deer for recreational interests can negatively impact rare or declining vegetation types and cause shifts in forest composition, structure, and productivity. Eventually, this will impact plants and many wildlife species as well as the health of the forest products industry. A more balanced approach and longer-term thinking is needed to ensure that all natural communities, other significant habitats, and the species associated with and dependent upon them are represented and sustained somewhere in the state.

Land Ownership: Special Roles and Opportunities for Ecosystem Management

Management of ecosystems, especially at larger scales, is largely shaped by the ecological characteristics of the management unit, land use history, landowners’ goals, and scale. Public and private landowners in Wisconsin have diverse management goals, financial expectations, and interest in biological diversity. The state’s public and private lands offer different opportunities for ecosystem management, and both play important roles in maintaining healthy ecosystems. It is important during planning efforts to assess opportunities that are generally best suited to public or private lands along with opportunities that may be limited primarily to specific ownerships. In some cases, ecosystem management may require coordinating management on a combination of public and private lands.

The majority of Wisconsin is in private ownership; therefore, private lands include a large portion of the state’s natural resources, provide habitat for numerous species, and contain many ecologically important aquatic and terrestrial communities. In much of Wisconsin, especially in the south, private lands comprise the ownership *matrix* that surrounds most of our public lands. Where this is not the case, private landholdings may “perforate” otherwise contiguous blocks of public land, influencing ecosystem processes and some management opportunities. Many species move freely between private and public lands.

Public lands comprise a much smaller area of the state, yet they are critical for the support and maintenance of the state’s biological diversity and provide many social benefits. Numerous rare species have been documented on public lands, and they often receive special consideration during planning and

management activities. Furthermore, public lands sometimes provide management opportunities that can be difficult on most private lands for the reasons discussed below.

Public Lands

In Wisconsin there are approximately 5.7 million acres of public land (roughly 16% of the state) (Wisconsin DNR 2006d), and its distribution is largely the result of historical land events. Many of our large public lands (such as national, state, and county forests) are located where early farming attempts by European settlers proved unsuccessful, often due to soils and climates that were unfavorable for agriculture. This partially explains the uneven distribution patterns of our public lands, which are much more concentrated in northern Wisconsin than in the south. The northern one-third of Wisconsin contains 75% of the public

lands, or about 4.3 million acres. Most of the large properties comprise “*working forests*” within a larger, regional forested matrix. The public lands in the northern counties generally provide the best opportunities to maintain large, contiguous areas of forest interior habitat with embedded wetlands, lakes, and *streams*. In aggregate, the county forests are the largest category of public lands in Wisconsin: the 29 county forests comprise over 2.3 million acres. Most county forestland (87%) is in the northern half of the state, and virtually all of the remaining acreage is in the Central Sand Plains Ecological Landscape. The Chequamegon-Nicolet National Forest is the largest single property in the state, encompassing over 1.5 million acres in 10 northern counties. Many state-owned or state-managed properties are located near county and federal landholdings, including the 225,000-acre Northern Highland-American Legion State Forest (the largest state-owned property) and the 90,000-acre Flambeau River State Forest. These extensive public holdings provide large-scale management opportunities, feature *continuums of natural communities* and *ecotones*, and contain important environmental gradients, such as moisture, slope, and aspect. The large public lands also provide habitat for many *specialists*, including wide-ranging species, interior forest species, and area-sensitive species, while providing opportunities for corridors and connectivity of habitats and species populations both within and across property boundaries.

Public lands are much less abundant in the southern portion of the state, but they are critical for many natural communities and species not occurring in northern Wisconsin. Outside of the extensive public lands (state, federal, and county) in the Central Sand Plains Ecological Landscape, public lands in southern Wisconsin are mostly managed by the State, are less forested than public lands in the north, and are often focused on wetland, grassland, or aquatic features. Public properties in southern Wisconsin are generally much smaller than their northern counterparts, with several notable exceptions such as the Black River and Kettle Moraine State Forests, the Kickapoo Valley Reserve, and the Lower Wisconsin State Riverway. These properties provide essential conservation habitats and are important for biological diversity. Many smaller state parks, wildlife areas, fishery areas, and natural areas exist in the south, often within a matrix of agricultural, and sometimes residential, lands. Significant federal ownerships in the south include several properties within the U.S. Fish and Wildlife Service’s National Wildlife Refuge system: Horicon, Necedah, and Trempealeau National Wildlife Refuges, the Upper Mississippi Wildlife and Fish Refuge, and scattered federal *Waterfowl Production Areas*. Lands and waters within Fort McCoy Military Reservation also deserve mention because they support many important natural features, including rare natural communities, undisturbed aquatic features, and numerous rare species populations. The public lands in southern Wisconsin are often small and stressed



Portion of the Lower Wisconsin State Riverway (LWSR) as seen from atop Ferry Bluff (Ferry Bluff State Natural Area). The LWSR surrounds 92 miles of undammed river with globally rare species and has over 40,000 acres in state ownership, providing a number of ecologically important management opportunities and species habitats in an area otherwise largely dominated by agriculture. Photo by Thomas Meyer, Wisconsin DNR.

by past land use histories and surrounding land uses, yet many support the last remaining *remnants* of certain natural community types (some of them now extremely rare) as well as the best remaining habitat for many rare or otherwise vulnerable species.

■ **Rare Species Management.** Many rare species populations and high-quality natural communities have been documented on public lands statewide, and they represent an important part of the state's biodiversity. Stein et al. (2008) described the importance of federal lands, including military lands, for supporting rare plants and animals throughout the U.S. In Wisconsin, a high percentage of the state's documented occurrences of rare species and high-quality natural communities are found on public lands. Although this is partially the result of greater biological survey attention given to the public lands, in many cases these properties

also have certain characteristics that allow rare species to persist. It is important to manage these public lands to protect and restore rare and representative habitats and rare species populations wherever possible.

■ **Management at Large Scales.** In general, public lands offer the best opportunities to manage large areas on a landscape scale. Broad, landscape-scale planning is an essential part of ecosystem management (Christensen et al. 1996, Franklin 1997) but is difficult to implement on smaller landholdings. While all public lands in Wisconsin are not large, the largest contiguous landholdings in the state occur on federal-, state-, or county-managed lands. Many opportunities to manage for forest interior species occur on northern public lands. The larger blocks of public land in the south, which can accommodate interior and area-sensitive species that are not found in the north, are also very important. Coordinat-



Landscape context and surrounding land uses impact management opportunities on any given site. Although these two Wet-mesic Prairie remnants appear similar superficially, they have very different opportunities and limitations. Both are State Natural Areas (boundaries shown in yellow) and contain native species, including some that are rare. However, Snapper Prairie (upper two photos) is only 30 acres and is surrounded by a fragmented agriculture-dominated landscape, providing limited habitat for many species. Conversely, Scuppernon Prairie (lower photos) is 185 acres and is part of a 3,000-acre wetland that includes another large State Natural Area. Community photos by Drew Feldkirchner, Wisconsin DNR. Aerial photos were taken in 2012 and are provided by the National Agriculture Imagery Program.

ing management among adjacent public properties can further increase the effectiveness of large block management.

The largest private landholdings, outside of tribal lands, are often corporate industrial forests, and these and other private lands are becoming increasingly fragmented. From 1997 to 2006, the number of private forest landowners in the state increased by 38%, and the average parcel size of privately owned forestlands decreased by 27%. Also, parcel size has decreased for landowners because many large parcels are being divided and sold (Wisconsin DNR 2010).

Large public lands or concentrations of public lands can help reduce the high road densities found elsewhere as more areas become developed. High road or housing densities limit options for biodiversity. Both of these factors have increased in many areas of the state in recent years (Radeloff et al. 2005, Hawbaker et al. 2006), leading to negative impacts on biodiversity and limiting the scale at which management can occur. Urban sprawl is well publicized, but rural sprawl caused by low-density residential development can also seriously impact ecosystems away from urban cen-

ters and is now common in many parts of the U.S. Areas of Wisconsin with the largest concentrations of public lands generally have lower concentrations of road density and housing development. As sprawl and other impacts continue, the remaining large properties or large habitat blocks will become increasingly important to help moderate the impacts of development on the state's biodiversity.

■ **Management Flexibility.** Some public lands have an important role in providing resources and opportunities not possible on private or county lands due to economic factors. Although most managers understand the importance of biodiversity, it is very difficult to assign it a monetary value (Lippke and Bishop 1999). Natural communities that are not economically valuable can be difficult to maintain on certain landholdings, whether public or private. For example, many past examples of barrens, jack pine, and "*scrub*" oak forests were converted to red pine (*Pinus strobus*) plantations to increase productivity, and prairies were almost all converted to agriculture except for tiny *relicts* found on steep hillsides or in wet areas. Privately owned industrial tracts and some types of public lands (e.g., county forests) have financial constraints that limit the ability to sustain certain natural communities. In contrast, some public lands are managed for broader purposes and may be in a position to develop long-term objectives for ecosystem management without having to react to economic market forces.

Public lands can provide opportunities to maintain features within working landscapes that can be difficult to support elsewhere because of economic constraints. For example, Franklin (1997) distinguishes ecosystem management in forests from traditional *silvicultural prescriptions*, in part, based on consideration for *snags*, downed logs, and other *coarse woody debris*. Historically, these features were only minimally retained because they were often viewed as wasteful from an economic standpoint. Maintaining forests beyond economic *rotation* ages is also constrained by economic costs. Old forests are uncommon and declining in Wisconsin (Wisconsin DNR 2010) and probably will always be rare throughout the U.S. (Hunter 1990). Some public lands designate areas in which to develop *old-growth forests* because of their ecological value, and the Chequamegon-Nicolet National Forest is required to maintain a certain percent of the property in old-growth management (Parker 2000). Where old-growth areas are not an option, extended rotations (cutting cycles) can provide many ecological values (e.g., Lindenmayer and Franklin 2002), but this may be financially undesirable for many private owner-ships. Finally, public lands offer some of the only opportunities to sustain certain tree species that are not managed commercially because they are difficult to regenerate or have low economic demand.

■ **Requirements for Broader Uses.** Public lands are often managed by agencies with missions and goals that include con-



Old-growth Northern Mesic Forest dominated by eastern hemlock (*Tsuga canadensis*), Oconto County. Hemlock saplings and a large-diameter downed log (sometimes called large coarse woody debris) can be seen in the photo; both of these ecological features are currently unusual in most of Wisconsin's northern forests. Photo by Thomas Meyer, Wisconsin DNR.

siderations for issues like biodiversity, water quality, and sustainability. These issues are often compatible with, and may necessitate, an ecosystem management approach. The Wisconsin DNR's mission stresses the importance of protecting and enhancing air, land, water, and wildlife, and there are numerous DNR administrative codes and handbooks with provisions for biodiversity-related objectives. Similarly, the U.S. Forest Service's mission includes sustaining the health, diversity, and productivity of the ecosystems they manage (USFS 2008). In contrast, goals and visions for private lands can vary widely, depending on personal values and economic objectives and may change rapidly.

■ **Requirements to Develop Management Plans.** Formal plans (within the Wisconsin DNR these are called “master plans”) are used to guide management on most public lands. These plans are periodically updated and revised to incorporate new information and respond to changing ecological and societal needs. Laws and/or public agency policies often require that these plans contain certain elements, such as specific provisions for animals, plants, and areas of ecological importance. For Wisconsin's state-managed properties, master plans are developed according to Wisconsin Administrative Code NR 44. This code provides definitions for important planning components, includes procedures for developing plans, and describes the minimum content required for a plan. Public involvement is an important requirement of NR 44. Other public agencies have similar requirements for soliciting input on their lands. The public is not typically asked to provide input for planning efforts on private lands with the exception of major development projects that require certain local and/or state permits.

Conducting planning for several public properties within a given area may reveal opportunities to coordinate and consolidate management, focus on the resources most in need of management attention, and promote ecosystem management. This approach is currently being used on some of the wildlife and fishery areas managed by the Wisconsin DNR.

■ **Requirements to Protect Rare Species.** Legal requirements and other protection for rare species can differ significantly among landowners in Wisconsin, and public lands have legal requirements that do not apply to private lands. For example, *threatened* and *endangered* animals are protected wherever they occur in the state, but threatened and endangered plants are only legally protected on public lands or in project areas involving federal funding. Although Wisconsin's state law protecting listed plants on public lands has exceptions for activities related to agriculture, forestry, and utilities, known populations of listed rare plants are often routinely protected on public lands.

Other voluntary guidelines on public lands are often in place to promote ecosystem management principles. For example, many public lands in Wisconsin (virtually all state lands and many county lands) are under *forest certification*,

requiring additional consideration for rare species and high-quality natural communities. The Chequamegon-Nicolet National Forest, while not currently certified, requires accommodations for species on the *Regional Foresters Sensitive Species List*; this list includes species not yet currently listed as threatened or endangered to offer some protection and management consideration and, hopefully, to prevent their future listing. The current Chequamegon-Nicolet National Forest Plan (USFS 2004) designates several *Research Natural Areas* (as well as other special areas designated for various levels of special management emphasis) because of the presence of sensitive vegetation, geological resources, and rare species.

■ **Long-Term Management.** Some public lands offer good opportunities to consider long-term objectives. A long-term perspective is needed since management decisions made for a property now will inevitably have consequences for the future. In forests, many changes will not be detected for generations, and the environmental and social contexts then may be very different than they are today (Swanson and Chapin 2009). Since public land ownership is typically stable over time, long-term and adaptive planning should be possible to accommodate. Private land can experience rapid turnover, making it very difficult to maintain management continuity because new owners may bring different objectives, values, or economic constraints.

■ **Working across Property Lines.** Working across property lines and/or administrative jurisdictions for projects involving multiple landowners is often a necessary part of ecosystem management and is sometimes easier on public lands. These efforts can be challenging, and the difficulty increases with the number of landowners involved. The ability to aggregate lands during planning and work collaboratively may be easier



Swainson's Thrush (*Catharus ustulatus*), a Wisconsin Special Concern species that is also on the U.S. Forest Service's Regional Forester Sensitive Species list for Region 9, a multi-state area that includes the Chequamegon-Nicolet National Forest. Photo by Jack Bartholmai.



Use of All Terrain Vehicles (ATVs) has become very popular on many public lands. This particular trail in Jackson County has been known to have 900 riders in a single day. This recreational use can present several management challenges. Photo by Peter Bakken, Wisconsin DNR.

when the associated properties are publicly owned. Although it can be possible to manage collections of smaller private landholdings as a group, it becomes increasingly difficult as private lands become fragmented and have many different owners. Landowner turnover can also result in changes in values and landowner objectives.

■ **Limitations on Public Land.** Limitations to managing ecosystems on public lands do exist for numerous reasons, and public land management is likely to be pulled in many different directions by diverse and sometimes well-organized interest groups. As public lands are typically managed for multiple uses, cultural and socioeconomic considerations may often override ecological considerations. Ironically, many of these social uses are dependent on sustainable natural resources and could disappear or be diminished if a long-term perspective is not taken. Some of these uses may be quite compatible with conserving biodiversity while others are more problematic. Attempts to provide the same uses everywhere can lead to *homogenization* and the loss of unique opportunities. The popularity of many public lands, coupled with diverse user groups, leads to many challenges, including the management implications of heavy recreational use. Invasive species may spread quickly on public lands as a result of recreational uses or related activities such as trail or road maintenance (Christen and Matlock 2009, Mortensen et al. 2009). Deer concentrations may become extremely high on some properties. This has happened in some of Wisconsin's state parks where deer may use the properties as *refugia* and cause damage to the native vegetation (Rooney et al. 2004). In the future there is likely to be demand for increased use of public lands to produce energy, fiber, and biomass as well as for places to sequester carbon, and it will be important to determine the appropriate roles

for public lands and how these uses would affect other important management opportunities.

Even with these limitations, the role of public lands is critical in Wisconsin, and their importance will likely increase in the future as natural habitats on private lands continue to be diminished. Whenever public land is acquired, it will be very important to determine whether or not the uses of such lands are sustainable, for both their ecological and socioeconomic values. For state-managed properties, the *Wisconsin Land Legacy Report* sets a framework for this discussion (Wisconsin DNR 2006d). As opportunities for new acquisitions become limited due to scarcity of land and/or funds, it will be increasingly important to determine how each potential acquisition can contribute to Wisconsin's overall ecosystem management goals.

Private Lands

Approximately 84% of the land in Wisconsin is in private ownership. For some species, natural communities, and other habitats, current public landholdings cannot support sustainable populations or viable habitats, making private land particularly important. This is especially true for wide-ranging species or those that are area-sensitive. Some species are dependent on habitat that occurs primarily or entirely in southern Wisconsin where public land is relatively scarce, and these species rely on private land to maintain their statewide populations (e.g., grassland birds). It will be difficult or impossible to buy enough public land to support these species in the south for numerous reasons, including social acceptability, land prices, ownership patterns, and availability of resources. These factors make public-private conservation partnerships essential, especially in southern Wisconsin but also on certain features in the north such as rivers, streams, and lakeshores.

Resources are likely to become more limited in the future due to increasing human populations and greater demand, and it will be important to assess those biodiversity and socioeconomic needs that cannot be provided by public lands in planning efforts. Important factors to consider in this assessment include the geographic pattern of public ownership relative to the distribution of ecosystem types, the scale of public ownership, the types of management needed, and the pattern comprising the *mosaic* of public and private lands within a given area. In addition to representing habitats or community types, it is also important to consider factors such as scale, context, condition, and changes over time (see the "Conservation Design" section below). A thorough assessment should factor in the needs of species with special habitat requirements, such as wide-ranging species; species sensitive to area, habitat, or population isolation or certain disturbances; and species that move seasonally that cannot be sustained on public lands.

In areas of the state with few public lands, the best opportunities for cooperation and collaboration may involve numerous privately owned properties. There are several

land trusts and other nongovernmental groups (NGOs) that develop such projects in Wisconsin, such as The Nature Conservancy, Gathering Waters Conservancy, Driftless Area Land Conservancy, The Prairie Enthusiasts, the Door County Land Trust, the Waukesha County Land Trust, the Driftless Area Initiative, Bayfield Regional Conservancy, and the Mississippi Valley Conservancy. These groups work to guide conservation efforts and can often work at scales or in time frames that public agencies cannot. The Wisconsin Landowner Incentive Program (LIP) helps private landowners create and manage habitat for species that are rare and/or declining by providing advice, management plans, and cost-share funding through the U.S. Fish and Wildlife Service. The federal **Conservation Reserve Program (CRP)** takes private land on erodible soils out of crop production and restores it to a more natural cover (grass or trees) that is designed to benefit soil, water, and wildlife conservation. The Agricultural Ecosystems Research Group, a consortium of Wisconsin DNR and University of Wisconsin researchers, is looking for agricultural practices that will be profitable to farmers but more sensitive to the environment, including the provision of wildlife habitat at certain times of the year. The Southwest Wisconsin Grassland and Stream Conservation Area is a mix of public and private lands managed to benefit grassland communities, both fauna and flora. The Glacial Habitat Restoration Area and the Western Prairie Habitat Restoration Area are large-scale efforts to manage private and public lands to benefit grassland and wetland wildlife. The U.S. Fish and Wildlife Service has a private lands program in Wisconsin to help private landowners manage their lands for conservation purposes. Many special interest groups (e.g., Ducks Unlimited, National Wild Turkey Federation, Wings over Wisconsin, Pheasants Forever, Madison Audubon Society) provide seed or plants and money to restore and provide habitat for wildlife on private land. All of these groups and others play important roles in managing natural resources in the state.

Public-Private Example: Foster Hill

The Foster Hill project is located in an area experiencing heavy residential development pressure and involves a partnership including a city and private landowners. Foster Hill Cemetery, the portion of the Kinnickinnic River Gorge Conservation Opportunity Area owned by the city of River Falls, is managed along with several private ownerships and an adjacent power line right-of-way to protect and enhance a population of the Federally Threatened prairie bush-clover (*Lespedeza leptostachya*).

The Wisconsin Landowner Incentive Program funded removal and herbicide treatment of invasive eastern redcedar (*Juniperus virginiana*), shrubs, and nonnative **herbs** from prairie and oak savanna habitats and also funded staggered **prescribed burns**. The St. Croix Chapter of The Prairie Enthusiasts organized the project and matched the work with seed collection and planting, mowing new plantings,

and follow-up removal of invasive herbs. Management of this site was based on a collective desire to maintain remnant prairie bush-clover populations and provide habitat for the other rare species and natural communities known from the area. This project is an excellent example of using partnerships to manage the last remnants of important natural communities and species habitats in an area of heavy urban and residential pressure where additional public acquisition may be difficult under the best of circumstances. The project includes a long-term commitment to maintenance and protection, with detailed benchmarks for measuring success.

Public-Private Example: Southwest Wisconsin Grassland and Stream Conservation Area

The Southwest Wisconsin Grassland and Stream Conservation Area is a large-scale example of collaboration among public and private entities. This project involves a diverse group of public agencies and private partners to conserve and enhance relatively functional grassland, savanna, and stream ecosystems in southwestern Wisconsin. Located within a rural farmland landscape of 460,000 acres in Dane, Green, Lafayette, and Iowa counties, the project focuses on managing, restoring, and enhancing the area's biological, cultural, economic, and recreational values.

The project involves buying, easing, and preserving large blocks of permanent grass cover within a matrix of privately owned and managed working farms. One of the primary goals is to establish three **Bird Conservation Areas (BCAs)** for declining grassland birds; these are large, open areas of at least 10,000 acres, each with a 2,000-acre core of permanent, contiguous grassland. Long-term sustainability of grassland birds like the Northern Harrier (*Circus cyaneus*) and Wisconsin **Special Concern species** Upland Sandpiper (*Bartramia longicauda*) and Western Meadowlark (*Sturnella neglecta*) depends upon these large, open landscapes with adequate acreage and appropriate grassy cover for nesting and feeding. Open landscapes with relatively high grass cover such as those found in the project area are now absent from much of Wisconsin and the rest of the upper Midwest, making this a particularly important conservation opportunity from a regional as well as local perspective.

Numerous native prairie remnants and prairie pastures occur within the project area, and many native plants and **invertebrates** are dependent on these relatively undisturbed **patches** of native prairie. Many of these will be embedded within the larger, managed areas of nonnative grass cover with the aim of increasing effective grassland area and restoring connectivity between patches of native prairie.

The Role of Rare Species in Ecosystem Management

The focus of ecosystem management is not rare species management but rather preservation of the composition, structure, and function of habitats and natural communities that

support all species (both common and rare) so that their populations are sustained and remain viable in the state well into the future. Each species has a unique role to play in our native ecosystems.

In this document, we have referred to species as “rare” if they occur on the Wisconsin DNR’s Natural Heritage Working List (Wisconsin DNR 2009b). This includes all species formally recognized as endangered or threatened by the State of Wisconsin or the federal government and also species categorized as “special concern” in Wisconsin. In other contexts, the term “rare” can be applied to local, regional, continental, or global situations. It may also refer to species with small population sizes or with narrow geographic or habitat distributions. It does not necessarily mean “endangered,” “threatened,” or “declining” (though it can mean any of those things), but it often means vulnerable to loss or **extirpation**.

The Wisconsin Natural Heritage Inventory (NHI) program is part of the DNR’s Bureau of Endangered Resources and has been in existence since 1985. It is a member of an international network of Natural Heritage programs representing all 50 states as well as portions of Canada, Latin America, and the Caribbean. Natural Heritage Inventory programs collect data on certain “elements of biodiversity,” including rare plants, rare animals, and high-quality or otherwise significant examples of all natural communities. The Wisconsin NHI database is the most comprehensive statewide source of information on the locations of Wisconsin’s rare species and ecologically intact natural communities. The Wisconsin NHI database stores locations for documented occurrences of the elements of biodiversity on the NHI Working List.

The Wisconsin DNR’s Natural Heritage Working List contains plants and animals listed as Endangered, Threatened, and Special Concern and also includes all natural community types and aquatic features recognized by the program. The Wisconsin NHI Working List is periodically updated and revised to reflect new information on the status and distribution of the state’s plants, animals, and natural communities, so users should always access the most recent version. The most recent Wisconsin NHI Working List is available from the Wisconsin DNR website (<http://dnr.wi.gov/>, keyword “NHI”). The Wisconsin NHI data used for this handbook were from the November 2009 iteration of the Working List.

A detailed discussion of the factors responsible for any given species rarity is outside of the scope of this handbook, but among the factors that can be responsible for species rarity are

- habitat loss, fragmentation, and/or isolation;
- habitat degradation;
- high degree of specialization;
- disturbance sensitivity (including reintroduction of those disturbances needed to maintain the community assemblage over time);
- genetic problems owing to small or isolated populations or other factors;
- exploitation;
- persecution; and
- parasitism, predation, or competition.

Species of Greatest Conservation Need (SGCN) were identified in Wisconsin’s Wildlife Action Plan (Wisconsin DNR 2005). This plan, funded by the U.S. Fish and Wildlife Service, only considered animals, but it could be expanded in the future to include plants. All animals listed as endangered, threatened, or special concern are included as SGCN, but other species were added to the SGCN list based on their relative rarity, regional or continental population declines, and potential risk of further decline.

Ecosystem management should ensure that common species remain common and do not decline to the point where they become rare and require expensive, specialized management at the individual species level. However, emphasizing management for widespread and common species, especially if it is done wherever possible in a state or region, can lead to ecosystem simplification and, across large scales, habitat homogenization and the decline of other species. In the case of rare species, this may even lead to their extirpation from a site, property, ecological landscape, or state.

The Role of Single Species in Ecosystem Management

Plant and animal (both vertebrate and invertebrate) species are often described as being found in and part of **assemblages**, **guilds**, and/or **communities**. A habitat or natural community approach to management is often the best strategy for maintaining a high diversity of plants and animals rather than focusing management on a single species. However, within a given habitat or natural community type, further consideration may be needed for certain features. For example, individual species may need specific plants, **microhabitats**, and ecological features (e.g., snags, abundant leaf litter) to survive and reproduce. Some species may also need a specific habitat developmental stage (e.g., early or late **seral forest**) and/or require large areas to maintain viable populations (e.g., extensive forest interior conditions or large contiguous areas of relatively homogeneous habitat). Though

all species have individual habitat needs, management of natural communities is still the most efficient way to manage for most species and to accommodate the many unknowns associated with all habitat management.

Some rare species may require individual management attention to prevent their extirpation from an area because of very low populations and/or very little remaining suitable habitat. However, even for these cases, there are usually opportunities to tailor management in ways that provide benefits to multiple species. For example, management for the Federally Endangered Karner blue butterfly (*Lycaeides Melissa samuelis*) could, in many places, be done in ways that would benefit numerous rare species while also maintaining a globally rare natural community type, Pine Barrens. Whenever possible, habitat management should be designed to support the entire natural community as appropriate for the site and its surrounding the landscape to effectively meet the habitat needs of any sensitive species present.

Managing to increase the distribution and abundance

of a single common species for the benefit of recreation or economic output needs to be considered within the realm of how other species might be impacted by this management. Increasing the abundance of a common species might be done without ecological harm if habitats for rare or declining species are also preserved, and their populations are maintained at viable levels. Managing the majority of habitats in the same way for the same limited set of featured species will result in a less ecologically diverse landscape that will not leave many management options for the future. Areas managed for a single species may not be resilient to changes (e.g., diseases, insect infestations, climate change) that are coming in the future.

Single species management focus may be needed to maintain extremely rare or vulnerable species in the state, but maintaining or restoring functional natural communities may be the most effective management alternative. Even in the case of the Federally Endangered Piping Plover (*Charadrius melodus*), now extremely rare in Wisconsin, the management emphasis (which includes protecting the birds from mammalian and avian predators and disturbances from motorized vehicles during the nesting season) has still been on protection of intact beach and dune habitat. Management for a single species to provide recreation or economic return should be done so that rare and representative habitats and rare species populations are being preserved in viable acreages and population sizes somewhere in the state. Managing for diverse natural communities rather than emphasizing a single species will provide the most resiliency to change and preserve the most management options that are likely to be needed by future generations.



An American marten (*Martes americana*) that was translocated and released into the North Central Forest Ecological Landscape in 2011 to augment a small population. This species has been the focus of reintroduction and monitoring efforts for several decades centered on two Marten Protection Areas. Marten abundance in one population area appeared to be viable and stable, while the other did not. Photo by Jim Woodford, Wisconsin DNR.



Piping Plover, a bird listed as endangered by both state and federal governments, has been a focus of recent protection efforts. Because of its extreme rarity in the state and the sensitivity of its breeding habitat, intensive work has been done for this species to monitor and protect individual nests from predation and other losses. Photo by Jack Bartholmai.

Conservation Design

Conservation design is a systematic approach to identifying ecologically important areas and determining how they can be maintained while accomplishing numerous other ecological objectives. It is a large topic for which entire books have been written (e.g., Groves 2003), and it incorporates numerous ecosystem management concepts, many of which are covered in other portions of this handbook. As with all ecosystem management activities, conservation design needs to be considered at multiple scales, especially the broad landscape scales, and sometimes across multiple property ownerships or land use designations within a single property.

Important Conservation Design Concepts

This section introduces some of the major concepts related to conservation design in Wisconsin. See also the “Ecosystem Management Planning” section above and the “Examples of Conservation Design and Ecosystem Management Planning” section below, which incorporate these and other related concepts into examples relevant to Wisconsin ecosystems.

Patch Size

Patch size is an important aspect of natural resource management, whether the principal objectives are for biodiversity or resource extraction. In addition to affecting habitat, patch size and the related concepts of habitat fragmentation and isolation also affect ecosystem processes (Forman 1995). Natural communities historically occurred in various patch sizes, largely as a result of factors like landform, topography, soils, hydrology, and natural disturbance regime. The following are examples of patch size categories for vegetation and their respective sizes:

- matrix habitat – tens of thousands of acres
- large patch – hundreds to thousands of acres
- medium patch – tens to hundreds of acres

- small patch – 1 to 10 acres
- linear habitat – better measured in meters, kilometers, or miles than acres. Cliffs and beaches are examples of linear habitats

Whether the primary goal for a particular area is to sustain high-quality natural communities or maximize resource production, it is important to assess the patch sizes and distribution at the planning and design stages. Some species require large patches of habitat, and larger patches provide numerous other management opportunities not possible on small patches. Large patches can also help to mitigate the effects of many human-caused disturbances. Conversely, the smallest patches consist mostly of *edges*. Since many portions of Wisconsin are now made up of numerous small habitat patches, broadscale management opportunities will often need to focus on “mosaics” of smaller areas. The matrix, or area between and around these patches, is very important for biodiversity (Prugh et al. 2008, Franklin and Lindenmayer 2009) because it makes up much of the landscape and will affect what is inside the area to be managed. Ideally, conservation areas would be large enough to accommodate natural and human-caused disturbances while still accomplishing habitat goals for natural communities, habitats, and desired species.

Patch Shape

Patch shape can be the result of numerous natural and cultural factors, including site topography and geography as well as natural and human disturbance histories. The shape of an area affects the relative amounts of edge and interior habitat. This can be a critical management consideration and planning issue where the intent is to conserve area-sensitive species that may be negatively affected by *edge effects*. The margins of human-derived patch shapes are often very different from those resulting from natural processes and can



Three examples illustrating major differences in patch size across the state and how they might impact management opportunities. All three photos are shown at the same scale and are (from left to right): Menominee County, perhaps the largest forest “patch” in the state; the Kettle Moraine State Forest – Northern Unit; and Olson Oak Woods State Natural Area in Dane County. Photos by Wisconsin DNR staff.

result in more high-contrast or “hard” edge, such as the abrupt transition between a forest and a cultivated field (Forman 1995). Landform, hydrology, or natural disturbances can result in abrupt ecotones but may also lead to “softer” ecotones between natural communities, such as the more gradual transitions that naturally occurred under a disturbance regime of periodic wildfire in the continuums from treeless prairie, to savanna, to woodland, and, finally, to **closed canopy forest**. Many wetland ecosystems offer parallel examples such as a transition from aquatic system to **emergent marsh**, then to wet meadow or low prairie, to shrub swamp, and eventually, to lowland forest. Management and planning efforts could keep these examples in mind and look for opportunities to positively influence the shapes of smaller patches with large amounts of edge and, especially, the transitions among adjacent units. This can be done through various means, including the timing of management and retention of certain structural characteristics, factors that are also important for ameliorating negative edge effects and quickening the recovery of an area to support species requiring more interior conditions than might be offered.

Landscape Context

Landscape context has an important effect on ecological processes and influences the function and viability of a given site; this is especially true for smaller sites. Housing density, road density, other developments, hydrological modifications, and land use are just a few of the factors that may impact a site's ecological integrity. Unlike nearby Michigan, Minnesota, and Ontario, Wisconsin has no large wilderness reserves where ecosystem processes, especially those that may be somewhat scale-dependent such as emigration/immigration of species, hydrological flux/storage, and large-scale maintenance of biodiversity, can function more or less naturally over large regions. Ideally, conservation areas would be large enough to accommodate natural disturbance regimes, although this would require very large areas in some cases, as evidenced by the 1999 **blowdown** at the Boundary Waters Canoe Area Wilderness in northern Minnesota.

The viability of small patches may be improved by embedding them within larger areas where the management is relatively compatible with maintaining the small patch of interest. For example, surrounding an old-growth forest reserve with an area in which extended rotation management is practiced can increase the effective size of a reserve (Hunter 1990). This cannot always be done within a single landholding, but sometimes there are opportunities to work collaboratively across property lines to manage a group of management units toward compatible objectives. Landscape-scale planning can be used to help identify these opportunities. At a minimum, a **buffer zone** of some type is usually considered important to try to improve site viability by minimizing negative impacts from the surrounding areas; this is often considered especially important for areas with significant biodiversity value.

The context of a management site may be a critical consideration during the planning process. For example, does the proposed management fit the ecology of the area, is its purpose clear, is it consistent with the current vegetation and patchwork of habitats, and is it consistent with management goals on adjacent lands? What resources are missing that should or could be there? Will the proposed management benefit the area's locally, regionally, and continentally important species and habitats? Does the proposed management conflict with any other ongoing management in the surrounding area? For example, **afforestation** of a significant grassland ecosystem that was historically prairie would not be compatible with the ecology or management opportunities offered by the site, and it could negate the efforts and associated costs of grassland restoration and management at adjacent sites.

Corridors

Corridors can be important for allowing animals and plants to move among otherwise unconnected and often isolated habitats (MacClintock et al. 1977). Large-scale natural corridors in Wisconsin include **riparian** areas of major rivers, the Great Lakes shorelines, and several other features, such as the Niagara Escarpment, an area of dolomitic limestone that outcrops in the Door Peninsula and other parts of northeastern Wisconsin. River valleys or shorelines that run north-south may be especially important to migratory birds, a phenomenon that has been well documented in the Mississippi and St. Croix river valleys, the Kettle Moraine State Forest, and along the west shore of Lake Michigan during fall. The size, composition (vegetation, habitat, and land use), context, and geographic orientation of such corridors



The Niagara Escarpment, a linear feature comprised of dolomitic limestone, extends for over 200 miles in Wisconsin. The escarpment provides habitat for several rare plant and animal species and offers ecological connections in areas that are mostly surrounded by intensive land uses. National Agriculture Imagery Program photo.

are important aspects of their function and utility as migration or dispersal corridors and as habitat for resident species. Smaller-scale corridors can be critical connectors between habitat patches, especially when these patches contain small isolated populations of species vulnerable to extirpation. Sometimes the corridor itself has habitat features necessary for certain organisms; for example, the links between *ephemeral ponds* and their surrounding forests provide habitat needed for some amphibians.

The corridor concept is complex, and there is some evidence that *artificial corridors* are much less effective than natural corridors (Rosenberg et al. 1997). Corridors will create some edge habitat that may or may not be desirable, depending on the area and the conservation opportunities and goals. Further, reduced contrast between habitat patches and the surrounding matrix may be just as effective as providing a discrete corridor (Turner et al. 2001). Especially where the deliberate creation of new corridors is being proposed, it is important to understand what is being connected and how the connection will affect other resources in the area and then weigh the trade-offs with other options. Increasing the size of the management unit and/or the suitability of the surrounding matrix may increase viability more than adding *linear corridors* (Rosenberg et al. 1997) where that is an option and where the intent of the corridor is to connect habitat patches. It is also important in conservation planning and design efforts to weigh the positive effects for a given corridor along with potentially negative impacts, such as facilitating the spread of invasive species or sediments and toxins following dam removal when they might negatively impact important microhabitats or species (J. Lyons, Wisconsin DNR, personal communication, February 25, 2010).

Continuum of Habitats

Another important conservation design factor is maintaining habitat connectivity by providing for a continuum of habitats (e.g., natural communities) across important environmental gradients. One example of this could be a moisture gradient starting at a river and continuing upslope to include marsh, sedge meadow, shrub swamp, and floodplain forest. This gradient could continue to include drier vegetation such as oak barrens and sand prairie, which may be found on *sandy outwash terraces* bordering river floodplains, and finally to upland habitats such as forests on the bluffs flanking the river and its floodplain. Maintaining the complex of communities and habitats along these intact gradients would provide the most ecological diversity and function and may also add resiliency in the face of environmental change over time (climate change would be one example, but short-term cyclical changes are also important to think about). This can provide for the habitat needs of many species that require more than one habitat to complete their life cycle (examples include *herptiles*, many invertebrates, birds, and others) and will better ensure that the needed habitats will be available as the environment changes.

Appropriate Scales When Enhancing or Maintaining Biodiversity

Maximizing species diversity (species richness) for animals on a local level has a long history in Wisconsin and elsewhere and has strong roots in some of Aldo Leopold's early work (Leopold 1933). Although this may be a good option in some cases, a more comprehensive analysis is needed for conserving biodiversity across the broader landscape. Some species require or are adapted to diverse habitats, including lots of edge and small habitat patches. Others require large patches of contiguous habitat of one kind. A particular site may provide excellent opportunities to connect to a larger contiguous habitat. By doing so, this site could provide habitat for underrepresented species and contribute greatly to overall biodiversity even though species richness on that isolated patch is not maximized. It is important to consider how each site fits into the larger picture.

For plants, local increases in diversity are often the result of recent colonization by nonnative species (Rooney and Waller 2008). In many cases, these nonnative plants include invasive species, ultimately leading to a reduction in the diversity of native plants, especially those that are sensitive to competition, *edge effects*, or excessive *herbivory* from high densities of white-tailed deer.

Natural Community or Species Distribution

Community or species distribution and representation can be meaningful to conservation design. Whether an area constitutes a portion of the core range for a species or community or whether it is near the edge of its range are examples of useful considerations. There may be few places to effectively manage for a given species or natural community, such as is the case for many narrowly distributed and geographically restricted species and natural communities. Examples include the beaches and dunes along the Great Lakes and the many rare species, some of them regional *endemics*, strongly associated with or dependent on them. In other cases, a site may contain a particularly high-quality example of a natural community or a large, potentially viable population of a species or group of species of high conservation concern, even though management opportunities do exist elsewhere.

Some natural community types exhibit a great deal of variability because they occur in diverse environmental settings, they have been very broadly defined, basic descriptive information for them is incomplete, or significant changes have occurred in all or parts of their ranges since they were originally described. As a result, there are community types with broad distributions that are represented by distinct variants in different parts of their state range, and sometimes these variants are associated with specific ecological landscapes or specific landforms or soil types within one or several ecological landscapes. The Northern Mesic Forest, for example, includes several distinct "subtypes." Northern Mesic Forest covers a large portion of northern Wisconsin, yet very few

conservation areas contain examples of nutrient-rich hardwood forests with species-rich herb layers. Conservation efforts should strive to represent the full range of ecological and geographical variability within community types.

Missing or Scarce Features

Missing or scarce features in the landscape are important to consider during planning. Although rare species populations, areas of high species richness, high-quality natural communities, mosaics of intact natural communities, or even the conservation or restoration of important ecosystem processes such as maintaining natural disturbance regimes may be obvious conservation targets, other important features may fall through the cracks during the planning process. It is also important to consider less discrete features that are missing from the landscape, including variation within community types, certain developmental and *successional stages*, and a range of patch sizes appropriate to the type and site. For example, although many of the major forest community types are common and widespread within their ranges, old forests are rare (Wisconsin DNR 2010). Along with the absence of old trees, the state's forests are lacking many of the structural attributes associated with old forests. Wisconsin currently contains very few relict old-growth forests (sometimes called "primary forests"), yet there are many places where the forests are getting older and starting to exhibit certain old-growth characteristics such as large/old living trees, large standing snags, abundant coarse woody debris, tree fall gaps and associated *microtopography*, such as *pit-and-mound* features, multi-layered canopies, and the presence of certain species associated with complex, older forests (Wisconsin DNR 2006a). These features should be considered opportunities during conservation planning. Even when a landscape or planning unit contains no older forests, there are opportunities to designate areas in which to develop these characteristics when the appropriate forest types are present. Hunter (1990) pointed out that where true old-growth stands are lacking, there is actually more opportunity for positive action since there is greater flexibility about how much future old-growth to designate along with where it should be located to better ensure long-term viability. The "Landscape Analysis and Design" process used to identify, designate, and conserve old-growth and other sensitive features on the Chequamegon-Nicolet National Forest included many of these considerations as well as others specific to the opportunities, responsibilities, and mandates associated with managing National Forest lands (Parker 2000).

Important Microsites and Remnant Habitats

Microsites and remnant habitats within larger natural communities can be important components of Wisconsin's ecosystems. Sometimes these areas are relatively small (a fraction of an acre). In some cases, there may be opportunities to expand remnant habitats, such as small remaining portions of formerly large prairies. Many features, such as



Large diameter dead tree, also known as a "snag" or cavity tree. These features are now often scarce in forests, although they provide important habitat for several species, including those that utilize downed woody debris after they fall over. They also contribute to nutrient cycling, and some tree species use well-decomposed logs as a seed bed to allow seedlings to become established. Photo by Drew Feldkirchner, Wisconsin DNR.



Even small Ephemeral Ponds, such as the example depicted here, can provide critical breeding habitat for certain forest-dwelling amphibians and invertebrates. Vilas County. Photo by Drew Feldkirchner, Wisconsin DNR.

rock outcrops, seeps, inland beaches, and ephemeral ponds, cannot be expanded; however, once identified, they can be accommodated during management activities through protection and by practicing compatible management in the surrounding areas. In either case, these features contribute to a site's ecological value in many ways and can provide critical habitat for native plants and animals and improve the site's biological diversity values. In some cases, such as ephemeral ponds, these features are a very important part of the food web. All of these features help to minimize the effects of simplification and homogenization that might occur otherwise. There are many examples of these microsites and habitat remnants, including those that may be found within managed forests or even in agricultural areas. Habitat remnants might include a patch of native prairie within extensive surrogate grasslands, a stand of natural origin red pine within an otherwise intensively managed aspen (*Populus* spp.) forest, or a small grove of older "legacy trees" (such as eastern hemlock, yellow birch (*Betula alleghaniensis*), and, or even eastern white pine (*Pinus strobus*) within an area of managed northern hardwoods.

Replication/Redundancy

Whatever the target(s) of the conservation efforts, it is important that they be represented by multiple examples whenever possible. Areas may be unequally impacted by invasive species, *stochastic events*, or their surrounding land uses, so important natural communities, rare species habitats, or other features should be supported in multiple locations throughout a given landscape. For example, in order to develop and maintain a component of old-growth forest in Wisconsin, numerous stands of the appropriate types would need to be designated because one storm could impact centuries of forest growth and structural development on a given site. As an example, the former "Big Block" at the Flambeau River State Forest, previously the largest remaining relict old-growth forest on state-managed land, was completely blown down by a single windstorm in 1977. *Replicates* are also important to factor into the conservation design process because no single stand can represent the full range of natural variability associated with any given forest community. Finally, replicates are sometimes needed for research and monitoring purposes to ensure that an adequate number of sites and/or acres are available to obtain valid study results.

Buffers and Managing for Compatible Uses

Landscape context is now understood to have very important implications for reserves and other conservation areas. *Buffers* are sometimes used around conservation targets to protect areas from being negatively impacted from the surrounding landscape. The idea of "*buffering*" a landscape feature or habitat is often associated with the strips of land that comprise riparian areas around waterbodies. However, buffers may also be valuable for protecting other sensitive

habitats, especially when high-intensity land uses occur in the surrounding areas. Rather than maintaining a linear area of a set distance to protect an area, it can be even more effective to manage the surrounding habitats in ecologically compatible ways while still achieving other objectives. For example, large reserves are often not possible, yet maintaining smaller *High Conservation Value Forests* within larger areas of compatible uses (such as small reserves within larger areas designed for timber production) can benefit numerous species and provide conservation opportunities that would otherwise not be available (Lindenmayer et al. 2006). Sometimes zones are used within management areas for this purpose; for example, a zone of moderate-intensity timber management could be used to separate a sensitive rare species habitat from an area of much higher intensity timber management or an area with heavy human use.

Implementing Conservation Design

Many tools and techniques can be used to implement the concepts from the last section; a few of these are described below.

Conservation Areas

Conservation areas are used to identify and protect ecologically important areas and archeological sites. They can have many purposes, including providing valuable benchmarks and acting as controls for comparison with other management units, and they can take many different forms on different landholdings. For example, High Conservation Value Forests include both forested and nonforested community types, and their identification and protection are required to maintain forest certification. They are identified on many state-managed lands in Wisconsin using criteria related to biodiversity and/or cultural significance. Some conservation areas in Wisconsin rely on temporary informal designations while others have formal long-term protection, such



Located in Jackson County, Bauer Brockway Barrens State Natural Area is jointly managed by the Wisconsin DNR and Jackson County. The site supports a diverse barrens flora and numerous rare species. Photo by Thomas Meyer, Wisconsin DNR.

as dedicated *State Natural Areas*. There are various reasons for the differences, including historical factors, ownership factors, the ecological quality of the site, and the rarity of the community or species present. Some of the typical reasons for identifying conservation areas are as follows (modified from Meffe and Carroll 1994):

- Large areas can provide “ecosystem services,” such as maintaining water quality or sequestering carbon. They can also provide species population sources and adequate habitat for area-sensitive and area-dependent species and processes, and they can maximize habitat and niche availability for a suite of species.
- Significant biodiversity criteria such as high species richness, a high number of rare species, or the presence of endemic species can be used to identify conservation areas.
- Intact biota that includes particular species or groups of species and/or high-quality communities can be important for conservation areas. These areas may also contain few nonnative species relative to other areas.
- Sites can be identified for numerous other reasons, including areas maintained mainly to provide hunting opportunities, watershed protection, research, education, aesthetics, and spiritual growth and well-being. These sites sometimes have high biodiversity values even if they were first identified for other reasons.

Identifying Opportunities to Conserve Biodiversity

Identifying opportunities to conserve biodiversity is an important part of planning and relies on numerous information sources as well as some level of biological field inventory. In Wisconsin there are many inventory (or survey) programs designed to track plants and animals. These programs all have strengths and limitations, and there are inherent trade-offs between the intensity of the inventory efforts and the amount of area that can be surveyed. For rare species, it is important to have a well-defined methodology for assessing rarity and uniqueness. The Natural Heritage Inventory programs in the U.S., Canada, and several Latin American countries use a system designed to track species and identify significant natural communities in a consistent and meaningful way (Stein and Davis 2000, Cutko 2009). The Wisconsin Natural Heritage Inventory (NHI) program stores rare species and high-quality natural community information in a statewide database where it is available for planning and many other uses by the Wisconsin DNR. (See boxed copy describing the Wisconsin NHI program on page 13 of this chapter.) The Wisconsin Wildlife Action Plan also provides information about the species tracked by the NHI, along with their important natural community and ecological landscape *associations*, and is a valuable resource for assessing conservation targets and opportunities. Finally, this handbook outlines many ecological opportunities in

Wisconsin’s 16 ecological landscapes that can be used to help identify targets for an area of interest.

Delineating Conservation Areas

Delineating conservation areas is often done opportunistically based on the presence of high-quality or unique features when they are found to be compatible with other management objectives. Sometimes areas are identified for particular species or groups of species occupying specific vegetation types, developmental stages, or *seral stages*. In some cases, rare species are the reason for identifying these areas, but they are often identified for maintaining common and widespread species and to provide hunting opportunities. There can be both advantages and limitations in using a single species approach from a biodiversity perspective, depending on the situation. Because there are far too many species in Wisconsin to manage all of them individually, a careful assessment is needed to look for compatibilities and conflicts among objectives. Where to do this kind of management and at what scale are very important planning considerations.

Groves (2003) described how a group of conservation areas would meet criteria he referred to as the “Four-R Framework”: representative, resilient, redundant, and restorative. Using these criteria, a group of conservation areas would, collectively, (1) represent the biological features in a region, (2) be resilient to disturbance, (3) represent given conservation targets multiple times within the group, and (4) restore conservation targets that don’t meet viability or ecological integrity requirements within the group. Although representing all of these excellent criteria may be difficult in practice, an adequate assessment of the expected impacts and effectiveness of proposed conservation areas is needed, at a minimum. Important factors to assess include the long-term ecological integrity and viability of a site under different management approaches, along with many other concepts discussed in this handbook, such as scale, landscape context, and composition.

Conservation Planning

Ecologically based planning efforts require a good understanding of landforms, soils, hydrology, and the area’s history, along with the sites, species, and communities present. This is often achieved, in large part, through biological inventories and by gleaning information from a variety of other sources. Planning can be complex because ecological considerations are just a part of the information discussed along with numerous cultural factors. Even when maintaining biological diversity is a primary goal for an area, it will not be unusual for multiple, sometimes conflicting, objectives to be presented, especially given the lack of suitable areas for maintaining diversity in some parts of the state. See also the “Property-level Approach to Ecosystem Management” section of this chapter for additional considerations for property-level planning.

Delineating Management Units and Setting Clear Management Objectives

Management units are often necessary for planning efforts to provide a framework for conservation and the implementation of ecosystem management. Management units can be developed based on the opportunities they offer and their ecological roles within the larger area as well as their relationship to the rest of the property (or other applicable planning unit). Whether or not management units are used, it is important to have clearly defined ecological objectives in place. Management objectives should be as unambiguous, effective, and achievable as possible, while allowing for adaptive resource management. These objectives will make long-term planning possible and provide essential information for future managers and planners. Well-defined ecological objectives will also help to ensure that management performed within the unit will be compatible with the goals for that unit itself as well as with the overall property goals. Ideally, the property goals will have already been determined with respect to the surrounding ecological landscape, the state, or an even larger area, depending on the resources present.

Some management units may have areas with shifting or rotating components, such as the burn units that are often delineated and used for managing sites with prescribed fire. The management plan would indicate the reason for the permanent and rotating components, the scale at which they should be established, and how frequently they are intended to shift. Three hypothetical landscape planning examples relevant to Wisconsin have been provided in the “Examples of Conservation Design and Ecosystem Management Planning” section below to illustrate these concepts.

Working Landscapes

Working landscapes can be important to the maintenance of the state's biodiversity, and sometimes simple management modifications can help to maintain the species that use these areas, including some that are rare. Although formal conservation reserves are sometimes necessary for maintaining biodiversity, in Wisconsin these areas represent a very small proportion of the overall land base, especially for community types containing commercially valuable resources. It is important, therefore, to consider ecological factors such as rare species occurrences, microsites that support critical needs of habitat specialists, and other important natural features to help maintain biodiversity in working landscapes. For certified Wisconsin forests, managers must demonstrate efforts to enhance and maintain these elements, and the Wisconsin DNR has begun identifying ways to do this in some handbooks and other documents (e.g., Wisconsin DNR 2009a).

Techniques based on “*ecological forestry*” (Franklin et al. 2007) concepts have been getting more attention recently in Wisconsin for their potential to address some of the missing structural features in many working forests. Depending on various factors, including the context of the site, these

techniques can protect or even enhance habitats for certain species that are adapted to “intermediate” levels of disturbance. For example, Black-throated Blue Warbler (*Dendroica caerulescens*), a Wisconsin Special Concern species that uses gaps caused by *windthrow* in older forests, sometimes uses the thickets of saplings and/or shrubs that may develop in canopy gaps resulting from logging within areas of extensive older forest. Other species may benefit from retaining extra dead and dying trees during harvests, as these “*biological legacies*” are now lacking from many stands and can provide numerous ecological benefits (Franklin et al. 2007). While this does not mean that any of these species necessarily require logging, it does illustrate how nontraditional ecological objectives might be considered during management activities in working landscapes such as managed forests.

Some working landscapes also present good opportunities to conduct broader-scale improvements such as consolidating or reconfiguring patches as well as eliminating roads or other infrastructure that may fragment habitat or facilitate the spread of invasive species.

Cumulative Impacts of Disturbances

Cumulative impacts of disturbances are not well understood. They are often not considered in planning efforts or management activities, despite their importance. Monitoring is expensive and time consuming, and changes to some natural communities (e.g., forests) occur over very long time periods that may not be understood during the span of a manager's career. Also, it is often difficult to determine the effects of conducting multiple successive management techniques on a particular area.

Cumulative impacts can also be important spatially because management actions that appear benign may have unintended consequences when combined with other activities occurring in the surrounding landscape. These consequences often go unnoticed but can apply even to popular practices that are widely perceived to have conservation benefits. Additional monitoring is needed to examine short and long-term impacts of individual and cumulative actions at multiple scales resulting from our management and conservation activities. In addition, an assessment of the overall extent and impact of a given ongoing management activity is needed to determine whether expansion or even continuation of that program is ecologically justifiable.

Managing for Uncertainty

Managing for uncertainty can strengthen the effectiveness of conservation efforts by maintaining our ecological “capital.” Managing natural systems involves numerous sources of uncertainty ranging from unseen environmental changes, fluctuations, and disturbance events to indirect food chain events, genetic issues, or the potential cumulative or collective impacts of numerous management decisions across a given area (e.g., Meffe and Carroll 1994, Groves 2003). A full range of options needs to be preserved if management

is to adapt to changing conditions, especially those that are unforeseen. For example, when the effects of climate change become better understood, it will be important to have many management options available as responses. This will be especially important in the future, given the uncertainty associated with climate change and the continued onslaught of stressors such as invasive species, changes in land use, and pollutants, along with a shrinking land base for managing natural resources.

Adaptive Resource Management

There is uncertainty virtually every time a management activity takes place in the natural world. Adaptive resource management is a formal approach to dealing with these uncertainties. This important tool of ecosystem management is often discussed but usually not well understood or applied in practice. It involves using management as a learning experience to be evaluated and, as needed, corrected to allow for continual improvement. Ecosystem management treats management prescriptions like working hypotheses (Franklin 1997), and activities should be designed to allow us to learn from these “experiments.”

Change is constant and unpredictable, and the management approaches we use today may not work in the future. The environment is changing, land use is changing, natural communities and habitats are changing, societal needs are changing, available financial and fiscal resources are changing, and political opinions are changing. Climate change is the most recent major ecological perturbation that will impact the way in which natural resources are managed in the future.

In addition to an ever-changing environment and societal needs, we do not know enough about ecosystems and their components to accurately predict how they will respond to management. For example, we do not even know all of the species that are present in the state at this time, nor do we have an adequate understanding of the many relationships between species and ecosystem functions. Because we are so far from having a complete inventory or an adequate understanding of the functional relationships among species within ecosystems, adaptive resource management is needed to help us deal with the constraints of uncertainty.

Adaptive resource management integrates science, social values, and economic interests in the decision-making process. In an idealized and formal sense (Walters 1986), it is a management process that has a structured scientific basis but embodies changes in our management approaches and techniques as we learn more. Goals and objectives are collaboratively developed by scientists, managers, and policy makers for the natural resources that society desires at a given time, and then many alternate management scenarios are considered to accomplish those goals and objectives. Models are developed to predict the results from each management alternative (these can be simple conceptual models),

and the best management prescriptions are subsequently chosen. The chosen management is then implemented using an experimental design to test whether the management approach is achieving the desired result. Monitoring programs are designed to collect the data necessary to test whether the management alternative does indeed accomplish the predicted results. If the management practice results in the desired outcome, it is continued or tweaked by the new knowledge gained to continually improve. If the management practice does not achieve the desired result or if societal goals and objectives change, then alternate management strategies are tried and tested. In this way, adaptive resource management enhances the “institutional memory” documenting the decision-making process while continually improving the scientific basis for our management decisions and advancing our knowledge of changing ecosystems. As management constantly takes place without answers to many of the important questions, we can learn from our efforts by using an experimental design to plan management and increase our knowledge about the effects of our management on natural resources by dealing with the whole rather than the individual parts.

The simplified steps of adaptive resource management are to

- set goals for sustaining resources and accommodating the needs of the public with natural resource professionals;
- develop possible management actions to achieve goals using the best scientific information available;
- develop models (which can be very simplistic) to predict the results of management actions to achieve the desired goals;
- choose management actions that seem most likely to succeed;
- apply management with an experimental design on a sample of sites to test whether the management practices are accomplishing desired goals;
- set up a monitoring program on a sample of sites to evaluate critical variables needed to determine if management activity achieved desired goals; and
- based on monitoring results, refine current management or select alternate management action.

Practical considerations in the application of adaptive resource management are necessary. However, the application of adaptive resource management should not compromise the scientific structure of the approach. For example, once the desired goal for a resource has been decided (e.g., we would like to see more old-growth characteristics in a managed forest), different management scenarios can then be considered that could achieve those goals. For example, one approach might be implementing longer rotation ages in forests managed with periodic selective harvests and leav-

ing more coarse woody debris after harvest; other management approaches would also be considered. Simple models using the information currently on hand can be used to predict if a management scenario might work. This can be as simple as a conceptual model based on expert opinion, but the point is to document what will be done under a management scenario and what the likely outcome will be. This step limits the management actions that need to be tested to the ones most likely to succeed and also helps identify the information that needs to be collected to determine if the management was successful. Once the most promising scenario is selected, then it should be implemented using an experimental design (e.g., replicating the management on a number of sites over a geographic region that is ecologically similar). A monitoring program needs to be developed that will collect the information needed on the chosen sites (not all management activities need to be monitored everywhere) to determine if the selected management practice worked.

By implementing management and documenting how the management was done on a number of carefully selected and replicated sites and then monitoring the variables critical to determining if that management was successful, the management practice can be tested to determine if it met the desired goals. In this way, the management techniques that work to meet goals under the current conditions can be determined at the same time more information is learned about the effects of the management action on the ecosystem. If the management action didn't work, the information gathered should help explain why, and there are alternative management actions that have already been identified that can be tested using the same process. At the same time, more information is learned about the ecosystem that is being managed.

Some of the benefits of adaptive resource management are as follows:

- Provides a structured scientific approach to test the effectiveness of management practices while we manage
- Addresses uncertainty and allows us to manage before we know everything about the functioning of ecosystems, documents what we are doing and why, and measures the success of the management action compared to the management goals that have been established
- Allows management responsiveness to relevant changes in our knowledge base and to conditions that necessitate a change in management direction, technique, or goals
- Provides a measurement of effectiveness, documentation of the reasons for implementing a given strategy, and responsiveness to outcomes
- Discontinues management that is ineffective or has unforeseen negative impacts
- Learns more about how an ecosystem functions and what effects management actions have upon it

Although much is unknown at this time about ecosystem function, management can continue and change as additional information becomes available. Initially, we could use our current management practices, but we should apply them with an experimental design that will allow us to understand the impacts these management practices are having on ecosystems. Additional research may be needed to determine the impacts of our management as they are related to ecosystem productivity, diversity, and sustainability, especially at large scales. With the structured approach of adaptive resource management, careful monitoring and testing of management hypotheses, and further research, we should have the scientific basis for management in this changing world.

For a detailed discussion of the mechanics of implementing adaptive resource management, see Holling (1978), Walters (1986), Margoluis and Salafsky (1998), or Williams et al. (2007). For detailed examples of adaptive resource management projects, see Johnson et al. (1993), Johnson and Williams (1999), and Marmorek et al. (2006).

Monitoring

Many monitoring activities are conducted across the state, yet natural resource management is seldom monitored for its effectiveness and impacts. Managing without monitoring the effects of our actions is not ecosystem management. Since ecosystem management relies on adaptive resource management, monitoring is a necessary component. Monitoring natural systems is difficult but essential to ensure that the management prescribed is being implemented and is accomplishing the established goals. It also helps to ensure that other species are not inadvertently being harmed. Although monitoring management effects everywhere for all species is impossible, some level of monitoring is necessary to assess the effects of management actions on habitats and species, especially those of conservation concern.

In addition to monitoring the effectiveness and consequences of management actions, monitoring species, communities, ecosystems, and landscape patterns is also needed to track changes of these resources over time. Where and how to monitor and at what intensity to monitor is a challenge. Monitoring needs in the state include an evaluation of both existing conservation areas (individual areas and the whole network of areas) and active management techniques, among numerous other topics. Before any monitoring programs are developed, clear goals and objectives need to be identified, and the monitoring techniques need to be tested to ensure that the information collected will provide the scientific information needed to evaluate management outcomes.

New methods for monitoring the functioning of ecosystems are being developed. Some of the most promising measures of ecosystem quality may be direct quantitative measures of indicators of ecological function. This monitoring approach could measure diversity (the ratio of biomass among various *taxa*) or productivity (total biomass per unit

of time). Another potential approach is the ongoing measurement of key nutrients, such as nitrogen levels, which may indicate whether ecological functions are operating at a sustainable level. Some of these procedures for monitoring ecosystems have already been developed but are costly at this time.

Measuring changes on a landscape scale is another promising technique. With the development of **GIS** and more sophisticated analyses of satellite imagery (to the point of identifying single, dominant tree species from satellite imagery), the opportunity exists for monitoring changes in abundance and composition of different ecosystems, although the high-resolution imagery is expensive at this time. In addition, high resolution air photos can also be used for large-scale monitoring. Satellite imagery and GIS analyses can sometimes be used to monitor ecosystem health or stress (such as pollution of aquatic ecosystems or outbreaks of disease/insects in forests). These analyses will allow measurements of critical landscape-scale components such as fragmentation, geographic isolation, connectivity, and the potential for gene exchange among populations that are essential to maintaining quality ecosystems. However, monitoring for many ecosystem components still requires good field-acquired data.

Examples of Conservation Design and Ecosystem Management Planning

The following examples illustrate ecological concepts and conservation design described in this handbook for planning management activities on a landscape scale. These are idealized examples for describing key concepts. No two real-life examples are alike, and numerous ecological and cultural factors may limit or enhance the ability to apply this information. The use of adaptive resource management to be informed by monitoring and shared results from ongoing efforts in similar habitats elsewhere is implied in all three examples.

Managed Dry Forest/Savanna Mosaic

Although intensively managed, the numerous complementary units of this example provide habitat for area-sensitive barrens species, protect an ecologically significant core area, and allow for intensive timber harvest (Figure 1.1). Two core barrens units are connected by a permanent corridor and managed using fire and other techniques to maintain favorable structure. Two high-quality barrens/prairie remnants with globally rare invertebrates and associated plant species are enclosed in one of the barrens management units, so limited resources for additional treatments like invasive plant control are focused here first.

The jack pine stands are harvested on a rotating, shifting schedule, so each stand periodically provides an early seral stage “temporary barrens” connected to the core barrens unit. Thus, an area with very low tree density is available at

all times for species requiring open habitats. Care is needed during management activities because all of the stands may contain rare flora or fauna. For example, site preparation following harvesting is tailored to maintain these species wherever possible (e.g., herbicides are avoided in some areas, natural regeneration is preferred, patches are created to increase sunlight on areas of documented rare plant populations, and tree diversity is enhanced where appropriate). These stands are particularly susceptible to invasive plants such as spotted knapweed (*Centaurea biebersteinii*), and management activities are designed to prevent their introduction and potential spread to the adjacent habitats.

The Northern Dry Forest surrounding all of these areas is dominated by tree species of natural origin. Sustainable timber production is the primary focus of this large unit, yet it also buffers and provides connectivity among the other habitats. Special considerations are routinely given to rare species and special microsites here (e.g., patches of rich, light-demanding flora, wetlands, or wetland corridors). Select live trees may be retained as biological legacies from the previous stands during harvest, contributing to species and structural diversity as well as **cavity trees** and coarse woody debris.

Managed Grassland/Agricultural Mosaic

Each of this example’s management units is maintained for its own separate objectives, yet each contributes to the overall goals for the area (Figure 1.2). The overarching objective is maximizing grassland habitat while protecting an ecologically sensitive core area. The core area is maintained as permanent grassland and supports both high-quality dry-mesic prairie remnants and rare species habitats. The Conservation Reserve Program (CRP) and pasture areas buffer and provide connectivity for the core area, helping to maintain total grassland habitat. Areas managed for rotating crops contribute to the open landscape at times, resulting in additional habitat during certain years. Timing of crop harvests is modified whenever possible to avoid negative impacts to breeding birds.

This idealized landscape includes minimizing impacts of nearby developments and protecting stream water quality in its design. Forested corridors such as fencerows have been progressively eliminated over time because they interrupt habitat and provide corridors for predators. See Sample and Mossman (1997) for excellent information regarding grassland management in Wisconsin.

Managed Forest Mosaic

This example occurs on a large public property with contiguous forest extending beyond the boundary for many miles (Figure 1.3). A road makes up the western boundary of the area. Sustainable timber management is the overarching goal, along with maintaining rare species habitats and other ecological characteristics. There are several low-impact recreational opportunities available here, including hiking, nature study, and hunting.

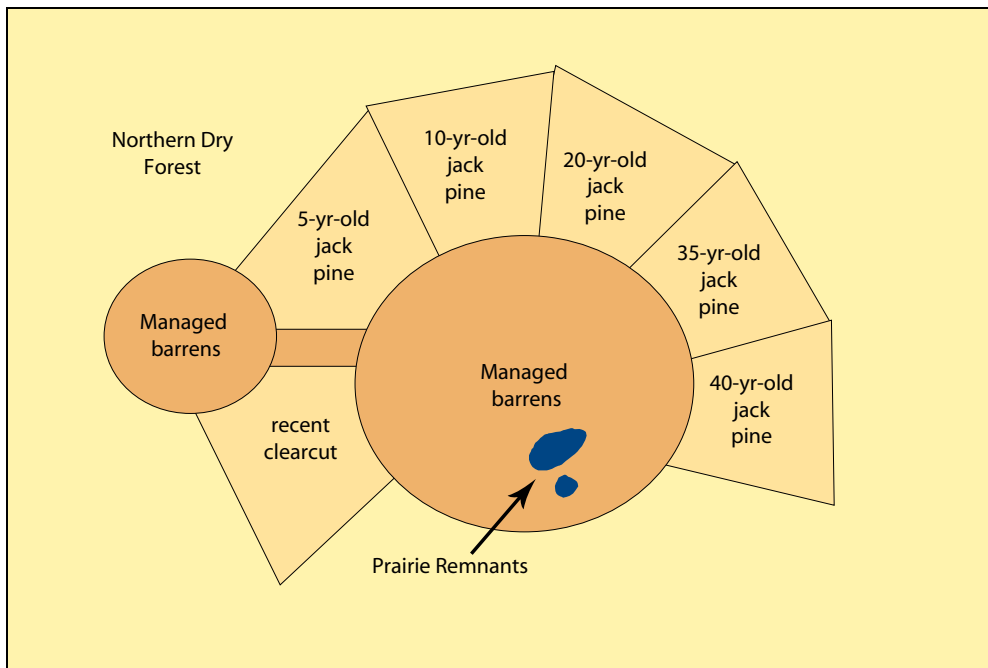


Figure 1.1. Intensively managed landscape of xeric (dry) communities and surrogate community types. Ecological landscapes most relevant to this example are the Central Sand Plains, the Northwest Sands, and the Northeast Sands.

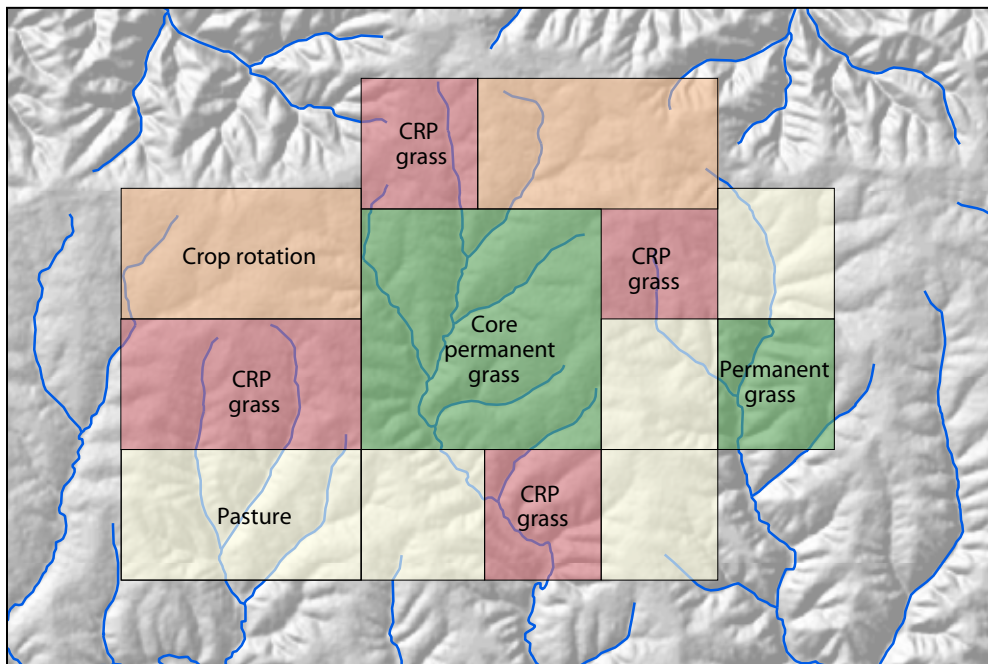


Figure 1.2. Managed grassland/agricultural matrix. Ecological landscapes most relevant to this example are the Southwest Savanna, the Western Prairie, and the Southeast Glacial Plains.

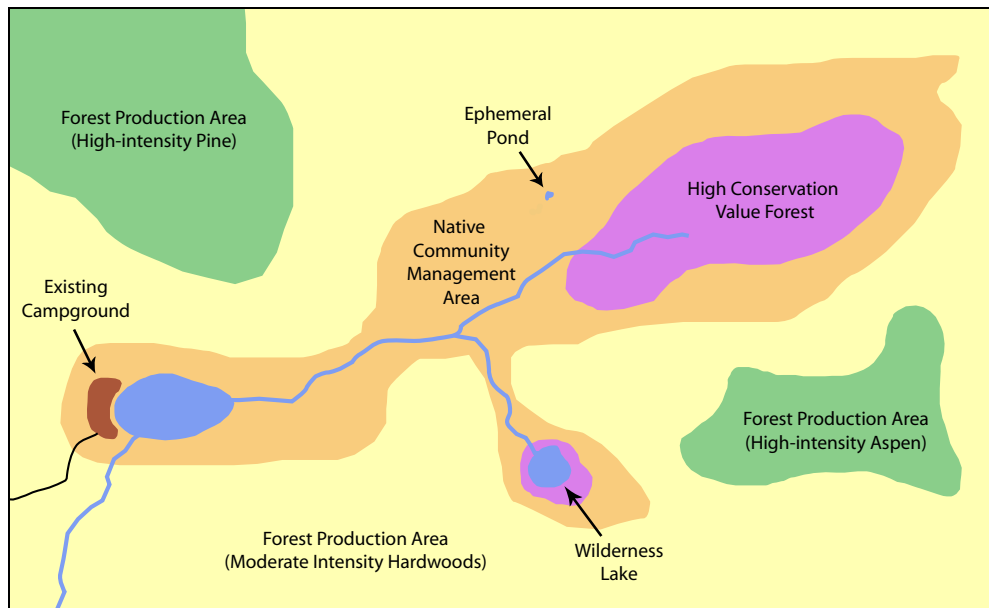


Figure 1.3. Managed forest landscape with areas of high conservation value, light recreation, and various timber management intensities. This example is relevant mostly to several of the northern ecological landscapes but could also apply to the Southeast Glacial Plains (e.g., in the Kettle Moraine State Forest).

Management here ranges from very intensive to almost completely passive. There are two high-intensity forest production areas: a set of pine plantations in the northwest corner and another dominated by young aspen. Both of these areas are intended to maximize timber production and would have little potential to be restored to other types, at least for the next several decades. A large forest production area dominated by uneven-aged hardwoods surrounds these and other management units. Although a “working forest,” biological legacies such as coarse woody debris and standing cavity trees have been maintained within the forest production areas. Special microsites such as Ephemeral Ponds and Forested Seeps are routinely accommodated during management. Prescriptions are also tailored in places to enhance habitat for the Black-throated Blue Warbler, which has been known to breed here regularly, and special consideration is also given to forest raptors and rare herptiles.

The native community management area is also dominated by uneven-aged hardwoods but has larger trees, a more diverse understory, and scattered small groves of relict old-growth conifers. Although actively managed, the primary objective here is to develop and maintain a “managed old-growth” structure, including large trees grown to biological maturity as well as abundant snags, cavity trees, and downed woody debris. Harvest entries are infrequent, and information from the Wisconsin DNR’s *Old-growth and Old Forests Handbook* (Wisconsin DNR 2006a) is used to guide management. Special habitats such as Ephemeral Ponds are protected here, and an active monitoring program is in place.

The term “High Conservation Value Forest” comes from forest certification standards, but these areas often include

nonforested areas. Such is the case here, where a stand of older eastern hemlock and eastern white pine surrounds a wetland complex that includes a spring and headwaters stream. The area was identified because of its high-quality natural communities and rare species habitat. Several rare species have been documented here, including Wisconsin Threatened Red-shouldered Hawk (*Buteo lineatus*), several wetland invertebrates, and a few plants. An Alder Thicket borders the stream and is used by Golden-winged Warbler (*Vermivora chrysoptera*), a Wisconsin Special Concern species also currently found in the young aspen stand. The native community management area provides a buffer for this high conservation area, and raptors use the large branches of its mature trees for hunting perches.

Planning and management activities consider important ecological connections among management units. For example, ephemeral ponds in the native community management area provide breeding and hibernation sites for amphibians that move to adjacent management units at other times of the year. This area is regularly monitored for rare species, and invasive plant control occurs in all of the management units.

Both lakes are undeveloped, with the exception of a small rustic campground built many years ago, and both have important biodiversity values such as rare wetland or aquatic species, important habitat or foraging base for some terrestrial species, and a mostly natural composition of fish, herptiles, and aquatic invertebrates. Campground impacts are localized, with only a narrow road that connects to the well-traveled asphalt road that is the western boundary of the example. A small trail allows users to explore the High

Conservation Value Forest since it and the wilderness lake are accessible only by foot.

The stream exiting the lake toward the southwest corner of the site is within the forest production area but is protected through a riparian corridor. The Wisconsin Threatened wood turtle (*Glyptemys insculpta*) has been documented here in the past. The DNR's Forestry **best management practices** (BMPs) for water quality (Wisconsin DNR 2006c) are used as a minimum. Since **setbacks** based strictly on distance do not always account for local landform characteristics, further setbacks are sometimes provided using topographic maps. Where small wetlands adjoin the stream, the upland buffer begins at the edge of the wetlands. Care is taken during harvests to avoid small sandy openings near the stream, and logging roads here are gated.

Management activities throughout the example landscape are done with temporal considerations and cumulative impacts in mind. Intensive harvests are kept localized within any given year, and long-term planning allows for consideration of cumulative effects on habitats. Seasonal modifications are used to protect species during breeding and migration periods, as needed.

Implementing Ecosystem Management

At first glance, the task of evaluating management actions from such large scales as the state, region, or continent may seem overwhelming. Likewise, it may seem daunting to consider the effects of a management action on all other species and natural communities in a large area. And it can be difficult to deal with constituency groups demanding more of their favorite products or recreation in perpetuity when trying to ensure the natural communities and the species that comprise them are sustained somewhere in the state.

No one person could do all of this work on their own, nor could they have the knowledge to articulate and synthesize copious amounts of information about species, communities, landscapes, and ecology in addition to the many other factors related to natural resource management, including the human factors. Ecosystem management is best done collaboratively, where groups of experts and representatives of various disciplines and other interested groups or individuals can all contribute.

General Approaches to Implementing Ecosystem Management

How can all of the previously discussed factors be considered at one time to determine the best course of action? This handbook, along with statewide plans that have already been written (see “Integrating Land and Water Management

Plans” below and Appendix F, “Some Important Natural Resource Plans and Assessments,” in Part 3 of the handbook), will provide much of the needed information. Cooperation and coordination among natural resource management programs will help to effectively manage the resources within a given ecological landscape. Ecosystem management planning may take some additional time up front but will pay huge dividends with more effective and less conflicting management in the future.

Coordinating Management among Programs and Partners

Planning for ecosystem management requires cooperation and coordination among different programs and partners that are doing land and water management in the same or neighboring ecological landscapes. A common vision of what resources should be managed within an ecological landscape needs to be developed collaboratively. The goals and needs for all programs should be considered. Undoubtedly, compromises will be necessary, including changes to existing management goals and objectives on some sites. This handbook provides information about recommendations for which resources could ecologically best be maintained in each ecological landscape.

Coordination among diverse groups with varying interests in the resources of an area will be needed, and efforts should be made to ensure that their needs are being met somewhere on the landscape. The ecological and social conditions and opportunities within an ecological landscape should be considered when setting goals and objectives for that ecological landscape. Again, compromises will be necessary given the many desires of a shrinking amount of natural resources. Management for one species or group of species everywhere in the state is not compatible with sustaining a full range of healthy ecosystems.

Coordination of land management with other public agencies (e.g., U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service) is sometimes possible since they may have some similar objectives for managing the natural resources on their lands. However, for any project, there needs to be social buy-in for it to be successful. Occasionally there are opportunities to coordinate management with farm-based programs such as the Natural Resources Conservation Service and their Conservation Reserve Program. In addition, there are many opportunities to coordinate land management and acquisitions with nongovernmental organizations such as The Nature Conservancy, Gathering Waters Conservancy, the Door County Land Trust, The Prairie Enthusiasts, and the Driftless Area Initiative.

Industries dependent on the sustainable extraction of natural resources to provide products for human use can, in some instances, manage in ways that are compatible with ecosystem management goals. For example, clearcutting jack pine on industrial forestlands in the Northwest Sands Ecological Landscape may benefit pine-oak barrens species

if the cuts are in the right place, of the right size, at the right time, and done with careful follow-up and site preparation techniques. It will take planning at multiple spatial and temporal scales to ensure that the harvest of jack pine for pulp is done in a manner that can benefit barrens species while providing sustainable forest products (see the “Conservation Design” section above for an example).

Integrating Land and Water Management Plans

There are many conceptual and operational plans for the natural resources of Wisconsin within and outside of the Department of Natural Resources (see Appendix F for a list of some natural resource plans and assessments). Some of these plans are statewide, some are regional, and some are property based in scope. Some are ecosystem or community based, and some address a single species or group of species. Most plans are for a specific purpose or goal, serving a particular program or clientele. Some plans try to increase species diversity on a single property rather than more appropriately looking at species diversity from a regional perspective. Some plans involve different groups working together to accomplish a similar goal. Others may be working at cross-purposes to achieve different goals, or too many goals, within the same area. To make the most efficient use of Wisconsin DNR personnel time and dollars, planners should explore opportunities to work collaboratively with other programs and partners wherever possible.

This handbook identifies important ecological opportunities in each of Wisconsin’s 16 ecological landscapes. It provides the information needed to make sure that most native species, natural communities, and important habitats are maintained somewhere in the state. The handbook identifies the best places in the state to manage species and habitats that are in need of additional management attention (see Chapter 6, “Wisconsin’s Ecological Features and Opportunities for Management,” as well as the “Management Opportunities for Important Ecological Features” sections in the individual ecological landscape chapters). The information in this handbook provides a framework into which other statewide and large-scale plans may fit.

Large-scale land and water management plans have been based on or can be coordinated with management recommendations found in the ecological landscapes chapters and the other recommendations in this handbook. The Wisconsin Wildlife Action Plan; the Fisheries, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative’s *Important Bird Areas* program; and the *Wisconsin Land Legacy Report* all address Wisconsin’s natural resources and provide useful information for planning and management within the ecological landscape format. Ecological landscapes also provide the context used for many of the analyses that support Wisconsin DNR master planning. Some basin plans for aquatic resources also include land management recommendations referencing ecological landscapes as well as water basins. Each of these

plans was prepared for different reasons, each has a unique focus, and they were mostly produced for a specific funding source. However, there is overlap among the plans in many areas as well as a good deal of agreement regarding ecological opportunities and high-priority sites (see the “Ecologically Significant Places in Wisconsin” map in Appendix H, “Statewide Maps” in Part 3 of the handbook). Coordination of objectives from this handbook and other plans and consolidating monetary and human resources from different programs, where possible, would provide a basis for the most efficient, informed, and effective management within each ecological landscape.

An Example Integrating Statewide Plans: the Western Coulees and Ridges Ecological Landscape

The Wisconsin Wildlife Action Plan identified 30 Conservation Opportunity Areas (COAs) within the Western Coulees and Ridges Ecological Landscape (Wisconsin DNR 2005), to maintain or increase wildlife Species of Greatest Conservation Need. The COAs are ranked in significance from global to statewide importance to help prioritize work and the expenditure of grant funds. State Wildlife Grant funding will focus work in COAs, especially those of global or regional significance, thereby addressing some of the ecological opportunities identified in this handbook.

The *Wisconsin Land Legacy Report* identified 39 places in the Western Coulees and Ridges Ecological Landscape that merit conservation action (Wisconsin DNR 2006d). This report identified lands of ecological and recreational significance that should be considered for purchase or other forms of protection over the next 50 years. Each of these “*Legacy Places*” is given two scores: one for conservation significance and the other for recreational potential. Acquisition and easement dollars could be used to accomplish conservation work on some of the places ranked as having high conservation value. These areas include many of the ecological opportunities of this handbook.

The Wisconsin Bird Conservation Initiative’s All-Bird Conservation Plan uses Important Bird Areas (IBAs) as the core for its key sites for bird management. Twelve IBAs have been designated within or partially within the Western Coulees and Ridges Ecological Landscape (Steele 2007). In addition to their importance for providing bird habitat, many of the IBAs are important for numerous other species and ecological objectives, and often they are the same sites identified in other plans. Protecting and maintaining these areas would address priorities identified in several other plans, including this handbook.

As a specific example, the extensive hardwood forests and the oak ecosystem (the continuum from oak savanna to oak woodland to oak forest) described in this handbook would be excellent priorities for the Western Coulees and Ridges Ecological Landscape that could address the needs of several plans. These ecosystems could be used to preserve and restore the globally rare oak savanna community identified in the

Wisconsin Wildlife Action Plan. These ecosystems are also ranked highly in the Fisheries, Wildlife, and Habitat Management Plan for maintaining and restoring oak savanna and southern forests, they are ranked highly in both ecological and recreational significance in the *Wisconsin Land Legacy Report* (Wisconsin DNR 2006d), and they include many Important Bird Areas. Ideally, these efforts would include the entire continuum of oak forest to oak savanna to dry prairie along the bluff tops of the Wisconsin and Mississippi Rivers as well as the sand prairies and oak barrens on the sandy terraces bordering big river floodplains. Significant parts of the **Driftless Area**, a continentally unique feature that occurs mostly in Wisconsin, could also be protected by these efforts. The Driftless Area includes those portions of southwestern Wisconsin and adjoining Illinois, Iowa, and Minnesota that were not covered by the Quaternary glaciers (Dott and Attig 2004). This has resulted in landforms, hydrology, land use patterns, and management opportunities that differ markedly from those that are common elsewhere in Wisconsin. (See the “Driftless Area” section of Chapter 6.)

A second specific example would be to protect, maintain, and restore habitat corridors along the large rivers (e.g., the Mississippi, Wisconsin, Black, and Chippewa rivers) in the Western Coulees and Ridges Ecological Landscape. These locations were identified as continentally significant in the Wisconsin Wildlife Action Plan, and they scored highly in the *Wisconsin Land Legacy Report* (Wisconsin DNR 2006d). Many Important Bird Areas are found within these locations, including several that are important components of the Mississippi Flyway. These areas could also address high priority work identified in the Fisheries, Wildlife, and Habitat Management Plan by maintaining wetlands and floodplain forests. Finally, these areas support large numbers of rare plants, animals, and high-quality natural communities. Some of the species are rare at the global level.

By integrating information from the existing statewide plans, along with the recommendations in this handbook, large-scale projects could be developed that address compatible goals from several plans. Combining funding and human resources would increase the efficiency of planning and management, providing results that are not possible by any single agency or organization.

A Potential Process to Implement Ecosystem Management

Two approaches could be used to implement ecosystem management. One is to take a comprehensive broadscale approach and plan for ecosystem management from a statewide scale. This has advantages in that it would provide a framework in which most management could fit, personnel time and money could be allocated to the resources most in need of management attention, and the best locations to manage both ecological resources and socioeconomic needs can be identified. The downside is that it may take a

year or more to get the infrastructure in place and complete more detailed analyses of ecological resources and socioeconomic needs.

The other approach is to use ecosystem management principles to make property-level decisions. The advantage of this approach is that it can begin immediately, but it may be harder to coordinate management activities across the state. In reality, management takes place at the site or stand level, and both approaches will be necessary to successfully implement ecosystem management.

Below are suggestions on how ecosystem management might be implemented using either approach in Wisconsin.

Comprehensive Broadscale Approach to Ecosystem Management

Using the principles of ecosystem management discussed above, a potential process to implement ecosystem management is suggested below. Steps one and two have already been completed.

1. Identification of resources within the state that are the most important for Wisconsin to manage from a multi-state, continental, or global perspective and identification of species that are rare, declining, or lacking in the state.

Several assessments identifying ecological resources that are especially important to manage in Wisconsin have been completed. The “Key Ecological Features in Wisconsin” section of Chapter 6, “Wisconsin’s Ecological Features and Opportunities for Management,” describes resources that are unique, well represented, and/or important for other reasons in Wisconsin.

The biodiversity report (Wisconsin DNR 1995) discusses seven major natural community groups in Wisconsin and provides recommendations for managing these communities. The “Statewide Community Assessments” sections of Chapter 2, “Assessment of Current Conditions,” assesses the status of the same seven major community groups and provides the global/regional importance and opportunities for managing these natural community types in the state.

The Wisconsin Wildlife Action Plan provides a list of species (see Appendix B in that report) for which Wisconsin has a relatively large portion of their global population in Wisconsin.

The “Flora,” “Significant Wildlife,” and “Management Opportunities for Important Ecological Features” sections in the individual ecological landscape chapters of this handbook provide more detail on which species, natural communities, and other habitats are important for Wisconsin to manage.

Basically, the information on what is important for Wisconsin to manage already exists. As ecosystem management planning proceeds, these species and natural communities should be given priority when deciding what resources will be managed and preserved.

2. Assessment of the ecological, socioeconomic, and recreational resources within the state's ecological landscapes and identification of the best management opportunities for each.

This assessment is the major topic of this handbook. Each ecological landscape chapter in this handbook describes the ecological resources and socioeconomic conditions that are present and identifies the best ecological management opportunities in each ecological landscape from a statewide, regional, and global perspective. The handbook further identifies some state properties that can contribute to the ecological goals for each ecological landscape that could be addressed through the master planning process. (See Chapter 6 for a table of important ecological features found in each of the 16 ecological landscapes.) This handbook also describes the socioeconomic conditions of each ecological landscape (see the “Socioeconomic Conditions” section in the individual ecological landscapes chapters). Attempts were made to identify opportunities that benefit both socioeconomic as well as ecological resources that were compatible with the ecology of the ecological landscape. This information can be found in the “Integrated Ecological and Socioeconomic Opportunities” section of Chapter 6.

The *Wisconsin Land Legacy Report* assessed resources that were in public ownership and estimated lands that would be needed for conservation and recreation over the next 50 years in each ecological landscape (Wisconsin DNR 2006d). This report identified 229 places that need to be preserved for ecological and recreational purposes in the state.

Recreational demands and uses in the state were summarized in *2005–2010 Statewide Comprehensive Outdoor Recreation Plan* (SCORP) (Wisconsin DNR 2006b). This document describes the recreational resources that are prominent in different parts of the state and what the likely recreational demands may be in the future. The SCORP report identifies recreational needs and opportunities for eight regions of the state. (The most recent SCORP report [2011–2016] was published after this material was written; the data from the 2005–2010 report were used herein.) These regions are larger but similar to the geographic location of ecological landscapes.

As ecosystem management planning moves forward, the information found in this handbook and other reports should be considered when deciding on what resources will be managed and where they will be managed in the state. This handbook and statewide plans should ensure that natural resources are managed in the best places in the state so that management is the most effective and efficient. In addition, it should ensure that the natural communities and the species that comprise them as well as most recreation desired by people are provided somewhere in the state.

3. Development of landscape-scale plans for each ecological landscape.

Based on the work described above, landscape-scale plans could be developed for each ecological landscape in the

state, identifying what and where ecological resources might best be managed, based on a statewide and regional perspective. Land ownership patterns should be investigated to identify opportunities to meet specific landowner needs as well as how they might contribute to the larger goals of the landscape. In addition, nature-based recreational and socioeconomic activities should be considered in these plans. This will require coordination and cooperation among different program managers and special interest groups to develop common goals for the ecological landscape.

Landscape-scale plans could serve as “umbrella plans” within which more specific plans (such as those listed in Appendix F, “Some Important Natural Resource Plans and Assessments”) might be coordinated and integrated. Landscape-scale plans should ensure that natural resources are being managed in the best places in the state and that all natural resources will be sustained somewhere in Wisconsin. These plans should also prevent conflicting management in the same areas or adjoining properties and assure special interest groups that their interests are being met somewhere on the landscape. Landscape-scale performance measures could be used to ensure progress is being made to address regional and statewide ecological goals.

As part of this planning process, the goals and objectives from existing individual statewide plans (see Appendix F) should be considered to identify how the needs of these specific plans can be met and still contribute to landscape-scale goals. Where possible, personnel and funding associated with these individual statewide plans should contribute to the goals of the broader landscape-scale plan. This effort should identify how specific properties and/or programs can accomplish their respective goals and yet contribute to the larger regional resources needing attention. Working with partners and other landowners (both private and public) will be very important in most areas. This approach may not be easy, but opportunities often become apparent using such a process. It may require that some properties change management to benefit regional or statewide goals. However, management to accomplish individual program goals might be increased elsewhere in the state. Using this approach should make it possible to meet the needs of the ecological resources or recreational activities in the most appropriate places across the state.

4. Implementation of the planning process.

The Ecosystem Management Planning Team could conduct workshops in different parts of the state describing the information that can be found within the *Ecological Landscapes of Wisconsin* handbook and outline how that information can be used to develop a landscape-scale plan. An example from each region could be prepared illustrating how the ecosystem management planning process would work. Plenty of time would be needed for questions and concerns.

Wisconsin DNR district ecologists might coordinate and develop the landscape-scale plans with regional staff, pro-

gram specialists from DNR's Central Office, and outside special interest groups. The Ecosystem Management Planning Team (EMPT) could provide assistance with the landscape-scale plan development and ensure a statewide perspective is being considered while developing the plans. The result of these landscape-scale plans should be a common vision of what the landscape should look like, ensuring that ecological diversity and management flexibility are preserved for future generations. The EMPT should provide a framework of ecological needs and priorities into which program goals and objectives as well as other statewide plans should fit. Part of this planning process will be to identify win-win situations where a program can meet its goals and still contribute to regional and statewide ecological needs.

A decision will need to be made on whether these landscape plans will be for general guidance and advisory or if they will become prescriptive and operational. Depending on whether these plans are advisory or operational, they may need to be taken to the Natural Resources Board for approval.

Regional ecologists could assist program managers (e.g., wildlife managers and foresters) to implement their work to meet program goals as well as to benefit regional and statewide ecological goals. Part of implementing these landscape-scale plans will be to identify available funding sources that will support the accomplishment of the goals and objectives for different programs and determine how these funds could legitimately be used to meet program objectives as well as benefit regional goals and objectives.

Once landscape-scale plans are implemented, rather than just using property or program performance measures, landscape-scale performance measures could be added to ensure that ecological resources are being managed from a perspective that is broader than an individual property or program perspective. Performance measures would ensure that progress is being made toward achieving regional and statewide ecological goals.

Implementation of large-scale planning and ecosystem management will require work up front to ensure its success. It is easier to do things as we have always done them and to do things we know how to do. It is more difficult to think broadly, change management, and integrate work with other programs or agencies. Many field staff already integrate programs and activities where they can, but this effort would be taking planning and integration a step further to meet regional and statewide ecological goals. Much of the work has already been completed in assessing which ecological resources are important to manage in Wisconsin and where they should be managed. Yet staff will need assistance to develop landscape-scale plans and find ways to implement them. By setting the course for implementing ecosystem management and expressing the importance of doing this, Wisconsin DNR administration can help implement the process.

Property-Level Approach to Ecosystem Management

Up to this point, we have been considering ecosystem management planning from a broadscale approach and from the vantage point of large scales. But what are managers to do when they are faced with developing a property-level plan? A question to consider in developing a property plan is: How does this piece of land fit with the broadscale ecosystems of the state or region? A property can be managed to help contribute to broader goals or to offset declines in desirable species and habitat conditions. Ideally, the property will already have a management plan that addresses broader goals, and the property plan will help achieve the preexisting goals. If there is no property plan, or if the plan does not consider broadscale issues, there may be an opportunity to address some of them in project-level planning.

A list of questions to consider when developing a property plan can be found below. (*Note: These considerations will not apply to every plan. They are pertinent when considering a change in the management of an area such as a forest type conversion, conversion of forest to open land, or reforesting an opening.*)

Landscape and Regional Considerations

- What kind of landscape is the property in? What is its capability? Do the physical environment (e.g., climate, topography, and soils) and natural disturbance regimes (e.g., fire, wind, flooding, and drought) make some kinds of management excessively difficult or damaging? Does the social setting make particular types of management extremely difficult?
- What kinds of projects have been common in this landscape in the past? What kinds of projects may be lacking? Are there projects that a majority of the public is asking for?
- Does this landscape have a local abundance of certain features or patch sizes that are scarce or declining at a broader scale? Are there opportunities to retain or compensate for a lack of such features elsewhere?
- What do we want this landscape to be like in 30 years? Do the projects being considered contribute to long-term productivity, conservation, protection, and restoration goals? Do they provide long-term opportunities for outdoor recreation and a healthy environment?
- Is habitat fragmentation an issue? Will the management in the plan isolate habitats or simplify the ecology of the property? How might the property plan affect broader-scaled landscape patterns?
- Does the plan provide for ecologically friendly recreational opportunities that may be scarce in the region?

- Are there any additional broadscale negative trends that this landscape has a role in counteracting, such as declines in species or communities?

Property-Level Considerations

- Does the property have an ecological theme or a unique ecological niche, based on its ecological content, current management goals, ownership, past uses, or people's expectations? Does the proposed plan fit with the theme?
- What plant communities and other habitats will be affected? How much of the community type exists in the state and surrounding landscape? Is the community type increasing, decreasing, being restored, or in poor condition?
- Is this the best place to implement the projects being proposed in the plan—within the state and the landscape—based on land capability, current conditions, and societal needs?
- Will the plan create linkages between habitats? Do these connections disrupt connectivity for other habitats (e.g., planting trees in a grassland matrix to connect *woodlots*)? Does greater connectivity facilitate the movement of invasive species into the area? If there are trade-offs in favoring one habitat over another, what kind of habitat is more important in the landscape, the region, or statewide?
- How does the plan affect patch sizes of vegetative communities in the area? Are there any area-sensitive species that might be affected by changes in patch size?
- Which species are being promoted by the plan? Are these species scarce or abundant at landscape and/or regional scales? Is management directed toward one species or multiple species? Are there indirect impacts on other species? How serious are they? Can they be mitigated?
- Does the plan identify ways to limit the spread of invasive nonnative species like invasive plants, insects, and/or diseases? Can these species be controlled over the long term within the landscape? Are projects included in the plan coordinated with other related projects so that control efforts will be meaningful over a larger land area?
- Does the plan contribute to addressing issues or opportunities that have been recognized at the state or regional level, such as in the Statewide Forest Plan, the *Wisconsin Land Legacy Report* (Wisconsin DNR 2006d), or this handbook?
- How will other activities in the landscape interact with activities proposed under this plan (e.g., ATVs, wildlife management, forestry operations) in the next 30 years?
- Does the plan foster social awareness of the history of the area (e.g., interpretive displays about American Indian cultures, reconstructions of historic buildings, or living history reenactments)?
- Will some of the projects in the plan help bring people together to achieve a common understanding of each other's values and goals and allow them to personally participate in managing the land?
- Does the plan contribute to aesthetic beauty in the area? Does it contribute to the health, safety, and well-being of the public, both now and in the future? Will it affect local residents' personal memories of and emotional attachment to the area?
- What future options, both environmental and recreational, might be foreclosed by this plan?
- What if we did nothing? Would undesirable changes occur? Why would these be undesirable?
- How will the public perceive this plan? Have their requests and concerns been addressed? If not, will a reasonable explanation be provided? Are they likely to participate in plan development again in the future?

Information Sources Helpful to the Ecosystem Management Planning Process

Much of the background information needed to begin ecosystem management planning can be found in this handbook. Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management," and the "Management Opportunities for Important Ecological Features" sections in the individual ecological landscape chapters should be especially helpful in identifying which resources are important to maintain in a given ecological landscape. In addition, a list of information sources (references and websites) where managers can find specific information about planning and about the natural resources in their area can be found below and in Appendix C, "Data Sources Used in the Handbook," in Part 3 of the handbook ("Supporting Materials").

Land and Water Management Plans

See also Appendix F, "Some Important Natural Resource Plans and Assessments."

- ◆ The 2004 Chequamegon-Nicolet National Forest Land and Resource Management Plan (<http://www.fs.usda.gov/detail/cnnf/landmanagement/planning/?cid=stelpdb5117262>) and the Final Environmental Impact Statement for the 2004 plan (<http://www.fs.usda.gov/detail/cnnf/landmanagement/planning/?cid=stelpdb5117673>)
- ◆ County forest plans
- ◆ Great Lakes Indian Fish and Wildlife Commission – <http://www.glifwc.org/>
- ◆ Karner Blue Butterfly Habitat Conservation Plan – <http://dnr.wi.gov>, keyword "karner blue."

- ◆ The Nature Conservancy's ecoregional plans: the Superior Mixed Forest Ecoregional Plan (http://science.nature-conservancy.ca/resources/docs/SMF_Ecoregional_Plan.pdf) and the Prairie-Forest Border Ecoregional Plan (http://conserveonline.org/library/PrairieForestBorder_FINALREPORT_wExhibits.pdf/view.html)
- ◆ Regional planning commission reports such as the one developed by Southeastern Wisconsin Regional Planning Commission
- ◆ Wisconsin DNR basin reports – <http://dnr.wi.gov>, keyword “basins.”
- ◆ Wisconsin DNR state forest master plans – <http://dnr.wi.gov>, keyword “master planning.”
- ◆ Wisconsin DNR Wildlife Action Plan – <http://dnr.wi.gov/topic/wildlifehabitat/actionplan.html>
- ◆ Wisconsin DNR's *Wisconsin Land Legacy Report* – <http://dnr.wi.gov/topic/lands/landlegacy/>
- ◆ Wisconsin DNR's *Wisconsin's Northern State Forest Assessments: Regional Ecology*
- ◆ Wisconsin DNR biodiversity report, *Wisconsin's Biodiversity as a Management Issue* – <http://dnr.wi.gov/files/pdf/pubs/rs/RS0915.pdf>

Broadscale Data

See also Appendix C, “Data Sources Used in the Handbook.”

- ◆ **Landtype Associations** and other terrestrial ecological units mapped at various spatial scales – See the “Land-type Associations” maps in Appendix K following the individual ecological landscape chapters. For additional information on ecological classification systems, see Appendix C, “Data Sources Used in the Handbook,” in Part 3 of the handbook, “Supporting Materials.”
- ◆ National Land Cover Data – <http://www.epa.gov/mrlc/nlcd.html>
- ◆ Natural Resources Conservation Service, Spatial soil datasets – http://www.wi.nrcs.usda.gov/technical/soil/soils_products.htm

Habitat, Species, or Site-Specific Data

- ◆ Wisconsin Breeding Bird Atlas website (sources where managers can find information on birds important to their area) – <http://www.uwgb.edu/birds/wbba/>
- ◆ Wisconsin Bird Conservation Initiative website – <http://www.wisconsinbirds.org/>
- ◆ Wisconsin EcoAtlas – <http://wiatri.net/EcoAtlas/index.cfm>
- ◆ Wisconsin DNR invasive species website – <http://dnr.wi.gov>, keyword “invasives.”
- ◆ Wisconsin Natural Heritage Inventory database – <http://dnr.wi.gov>, keyword “NHI.”
- ◆ Wisconsin DNR Wisconsin Wetland Inventory – <http://dnr.wi.gov>, keyword “wetlands.”
- ◆ Wisconsin DNR Endangered Resources Biotic Inventories (select projects are available online: <http://dnr.wi.gov/topic/NHI/NHIreports.asp>, data sheets, and unpublished data (e.g., State Natural Areas [SNA] Inventory, by county). Some SNA pages have species lists (<http://dnr.wi.gov>, keyword “SNA”). More information can be found on the Wisconsin Endangered Resources program species and natural community web pages, available at <http://dnr.wi.gov>, keyword “ER.”
- ◆ Wisconsin Geological and Natural History Survey – <http://www.uwex.edu/wgnhs/>
- ◆ Wisconsin Herpetological Atlas Project – <http://www4.uwm.edu/fieldstation/herpetology/atlas.html>
- ◆ Wisconsin State Herbarium (<http://www.botany.wisc.edu/herbarium/>) and Freckmann Herbarium websites (<http://wisplants.uwsp.edu/>)
- ◆ Local studies and publications that provide information relevant to specific questions

Appendix 1.A. *Scientific names of species mentioned in Chapter 1.*

Common Name	Scientific Name
American marten	<i>Martes americana</i>
Aspen	<i>Populus</i> spp.
Black-throated Blue Warbler ^a	<i>Dendroica caerulescens</i>
Eastern hemlock	<i>Tsuga canadensis</i>
Eastern red-cedar	<i>Juniperus virginiana</i>
Eastern white pine	<i>Pinus strobus</i>
Golden-winged Warbler	<i>Vermivora chrysoptera</i>
Jack pine	<i>Pinus banksiana</i>
Karner blue butterfly	<i>Lycaeides melissa samuelis</i>
Northern Harrier	<i>Circus cyaneus</i>
Piping Plover	<i>Charadrius melodus</i>
Prairie bush-clover	<i>Lespedeza leptostachya</i>
Quaking aspen	<i>Populus tremuloides</i>
Red pine	<i>Pinus strobus</i>
Red-shouldered Hawk	<i>Buteo lineatus</i>
Reed canary grass	<i>Phalaris arundinacea</i>
Ruffed Grouse	<i>Bonasa umbellus</i>
Spotted knapweed	<i>Centaurea biebersteinii</i>
Swainson's Thrush	<i>Catharus ustulatus</i>
Upland Sandpiper	<i>Bartramia longicauda</i>
Western Meadowlark	<i>Sturnella neglecta</i>
White-tailed deer	<i>Odocoileus virginianus</i>
Wood turtle	<i>Glyptemys insculpta</i>
Yellow birch	<i>Betula alleghaniensis</i>

^aThe common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

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